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Subject: Question ITU-R 119/9

PRELIMINARY DRAFT REVISION OF ITU-R RECOMMENDATION F. 1191, "BANDWIDTH AND UNWANTED EMISSIONS OF DIGITAL RADIO-RELAY SYSTEMS"

1. Introduction

This paper contributes to studies concerning unwanted emissions [1] and proposes minor changes to ITU-R Recommendation F.1191. This contribution highlights considerations for point-to-multipoint (P-MP) radio systems, stations assigned a block of spectrum, and situations where several stations operate under a single license over a geographic area. In many cases, the concepts also apply at the edges of allocated bands in general. The paper proposes that unwanted emissions that fall outside an assigned band should be restricted, but that emissions within an assigned band should not be restricted other than to the level of intentional emissions[1]. The paper further proposes that unwanted emissions below the spurious emission level should not be restricted.

The ITU-R has adopted several recommendations associated with unwanted emissions [2,3,4]. The recent development of new P-MP systems that use several transmitters, each occupying part of an assigned band, provides new perspectives on unwanted emissions issues. P-MP systems are evolving as a sub-set of digital radio relay systems (DRRS). Unwanted emissions recommendations for DRRS transmitters are contained in ITU-R Recommendation F.1191. To date, ITU-R Recommendation F.1191 primarily addresses point-to-point systems and systems assigned using channelized-band plans.

Several ITU documents [2,3,4] attempt to address multi-carrier operations by allowing emission limitations to be calculated relative to the 3 dB bandwidth of the final amplifier. While this method is appropriate for some systems, in many systems the 3 dB bandwidth of the amplifier is not related to an assigned-band edge or the occupied

[1] For this paper, the terms "authorized" and "assigned" bands use the ITU-R Radio Regulation 1-3 definitions where the ITU designates "authorized" bands for use by specific radio services and administrations "assign" licensees bands for station operations. An edge of an authorized band normally coincides with an edge of an assigned band. Administrations often partition or invoke channel plans within an authorized band so that many assigned bands fit within an authorized band. Within this paper, the term "license" refers to the generic method used by an administration to grant a station authorization.

bandwidth of the emission. It is suggested that additional restrictions are needed when using amplifier bandwidth as a term in an unwanted emissions mask.

2. Recent trends in Station Licensing Methods

As a result of de-regulation and other events, administrations now commonly issue station licenses for geographic areas and blocks of spectrum, e.g. wide-band personal communications service (W-PCS) and local multipoint distribution service (LMDS). The licensee normally installs several hub stations to provide coverage throughout the license area. LMDS systems use point-to-point (P2P) and point-to-multipoint (P-MP) radios to deliver service. Many administrations have historically invoked channelized bandplans [5] and many ITU-R recommendations assume that channelized bandplans are used. The use of area licensing eliminates the need to invoke channelized bandplans.

For the systems mentioned above, self-management of interference between stations in the coverage area is a significant part of the system design. A licensee may place payload signals anywhere in the assigned frequency block. If the administration doesn't invoke a specific channel plan, the licensee may develop a channel plan to match the local market. Payload signals are typically subject to maximum EIRP and coordination near license area boundaries. For proper operation of the array of stations, the licensee manages unwanted emissions within the assigned band in the best way to deliver services to subscribers. Although unwanted emissions are normally kept to low levels, in some cases the most cost-effective solution is to allow some unwanted emissions in order to obtain lower equipment cost. Within an assigned band, the licensee should have the freedom to choose the best approach to manage unwanted emissions rather than having to adhere to regulatory requirements beyond EIRP and coordination rules.

3. Point-to-Multipoint System Architecture

New P-MP systems have several stages of amplifications, RF combining and transmission between the modulator and the antenna [6,7]. The bandwidth of the amplifier may or may not relate to the occupied band of the emission.

P-MP radio systems have several bandwidths as a modulated signal is processed through various combiners, upconverters, mixers, and amplifiers. The occupied bandwidth of a single carrier might be 2 MHz, a channel perhaps 30 MHz, and the final upconverter/amplifier may have a 300 MHz bandwidth. P-MP transmitters may use a block upconversion architecture for the final upconverter/amplifier. The block upconversion method allows amplifiers of identical design and filtering to be operated on different frequencies and different assigned bands. Wave-guide filters are often used to limit out-of band emissions that occur outside an assigned band. The center frequencies of signals are adjusted by tuning the intermediate frequencies but not the final amplifier or upconverter. Typically, the transmission would not fully occupy the bandwidth of the final mixer/amplifier.

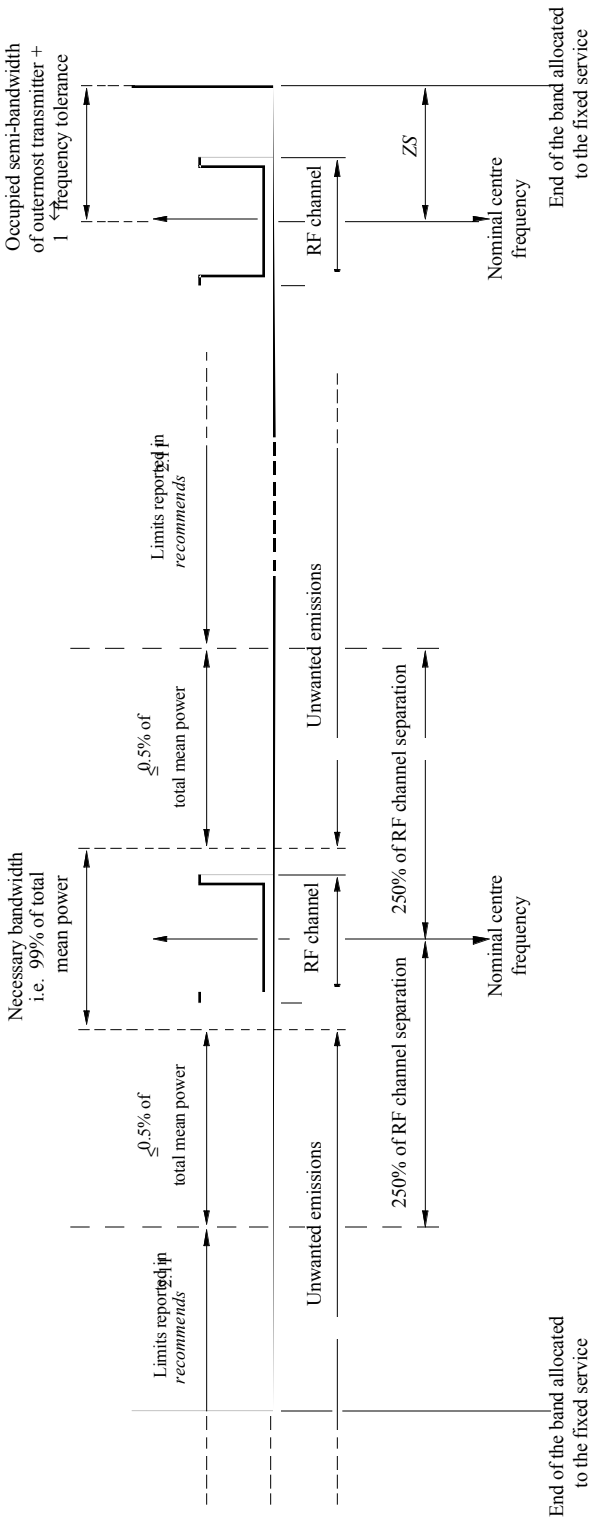
Hub stations that fully utilize the assigned band are normally built using several transmitters that each operate in a portion of the assigned band. A transmitter typically transmits multiple carriers, although they could be widely spaced in frequency within the bandwidth of the final upconverter/amplifier.

4. Desired Emissions

Desired emissions are characterized by necessary bandwidth, nominal center frequency, and power level as shown in Figure 1, which is reprinted from [4]. For this paper, the desired emissions occur at frequencies within an assigned band. The assigned band may occupy several channels or may have no channel assignments. The necessary bandwidth may include several carriers.

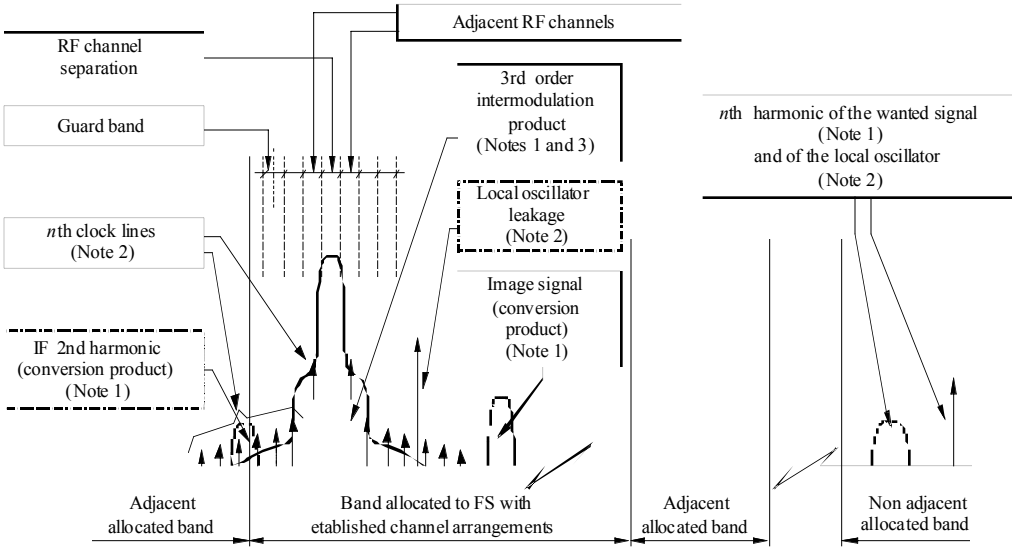
FIGURE 1

Unwanted emission attenuation objectives and bandwidth definitions of DRRS



As a product of desired emissions, transmitters also emit undesired signals such as those shown in Figure 2. Figure 2 is reprinted from [4].

FIGURE 2
Frequency bands and unwanted emissions of a digital radio-relay system (typical scenario)



Note 1 – Example of noise-like component of unwanted emissions.

Note 2 – Example of discrete component of unwanted emissions.

Note 3 – Non-linearity due to transmitter results in out-of-band emission which is immediately adjacent to the necessary bandwidth, due to odd order intermodulation products.

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4.1. Necessary and Occupied Bandwidth

Knowledge of the necessary bandwidth, Bn, of a transmission is required both for specifying the out-of-band emission limits (since the abscissa is normalized to the necessary bandwidth) and for determining the boundary beyond which spurious emission limits apply.

The definition of necessary bandwidth depends on the modulation method. For digitally modulated systems, recommendation 2.2 of [4] defines necessary bandwidth to be the same as the occupied bandwidth. Recommendation 2.4 states that the occupied bandwidth be measured or calculated by integration of an emitted spectrum. Emission designators are also related to occupied bandwidth as suggested in recommendation 2.3 of [3]. Multi-carrier transmission is comprehended within the emission designator system.

Occupied bandwidth is defined as the frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage _/2 of the total mean power of a given emission (RR Article 1, No 147). Note that for the percentage _/2 to apply to the lowest and highest frequency carrier in a multi-

carrier emissions, that a number less than _/2 must be used as a percentage of the total power in a multi-carrier emission. If the same value of _/2 is used for a single carrier and a multi-carrier emission, then in a multi-carrier case a portion of the necessary emission of the lowest and highest frequency carrier will be incorrectly designated as outside the occupied bandwidth. On the other extreme, if the value of _/2 made too small, then broadband noise-like emissions from a transmitter that are not related to the intended emission can dominant emissions outside the necessary bandwidth. In other words, if _/2 is too small the occupied bandwidth can appear to increase substantially beyond the bandwidth necessary for the emission. Because the noise like power at frequencies below an intended emission may differ from the power at frequencies above an emission, the value of _/2 may need to be different on each side of the intended emission. Note that, when measuring occupied bandwidth, the frequency span setting of the measurement instrument can influence the value of occupied bandwidth reported by the instrument.

Given the above discussion, the _/2 values above and below a multi-carrier emission should be adjusted such that the frequency below the lowest carrier and above the highest carriers are the same as if the lowest and highest frequency carriers were measured individually.

Recent revisions to ITU-R Recommendation SM.329 [3] and other ITU-R documents acknowledge multi-carrier operations such as those often implemented in satellite transponders systems and P-MP systems. The recommendations allow the 3 dB bandwidth of the amplifier to be used as the necessary bandwidth. For many P-MP systems, the 3 dB bandwidth of the final stage may be several hundred MHz, but the occupied bandwidth may be only a few MHz. Using the 3 dB bandwidth of an amplifier capable of operation over several hundred MHz results in an OOB mask that covers much more spectrum than necessary to accommodate unwanted emissions due to modulation products. It is suggested that for the purpose of OOB mask calculations, the 50% frequency offset point should not extend outside the assigned band even if the amplifier is capable of such transmission.

As another example of how defining unwanted emissions relative to the 3 dB bandwidth can cause undesired results, consider a solid-state amplifier capable of amplification from 1 to 8 GHz. Taking the current wording in the recommendations literally, an emission mask based solely on amplifier bandwidth allows 7 GHz of necessary bandwidth and unwanted emissions that span several frequency allocations. Equipment vendors are motivated to lower equipment cost. Designing an amplifier that can support the largest market, including several allocated bands, usually results in the lowest cost. Some restrictions other than amplifier bandwidth are needed to determine the necessary bandwidth for mask calculation purposes.

Draft CPM text for WRC-2000 states that the amplifier bandwidth can be used to determine the necessary bandwidth for narrow or un-modulated signals [1, Annex 9,

p.124]. It is suggested that, as stated, substantial abuse of the definition could occur by equipment vendors. Without additional restrictions, a wide-band amplifier covering several allocated bands could be used to determine necessary bandwidth. Several harmonics of the fundamental signal could be emitted, without limitation, if the 3 dB amplifier bandwidth is used to determine necessary bandwidth. It is recommended that occupied bandwidth be used to define the necessary bandwidth of narrow or un-modulated signals.

4.2. Center Frequency of Emissions

The distance ZS noted in Figure 1 is set so that the nominal center frequency, Fc, of the intended emission is within the assigned band. The distance ZS is normally at least half the necessary bandwidth plus the frequency tolerance of the transmitter.

The center frequency of an intentional emissions should be determined as the center frequency of the occupied bandwidth frequencies rather than using parameters related to the 3 dB bandwidth of the amplifier.

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4.3. Mean Power and Power Spectral Density

Masks have historically been calculated relative to the total mean power of the emissions. The advent of broadband digitally modulated signals has made the use of spectral density popular.

For digitally modulated signals power is often specified as a spectral density. For broadband signals, power ratios can be defined in **dBs** units as the ratio of the power spectral density at a frequency with respect to the mean power spectral density measured within the occupied bandwidth [1, Annex 11, p. 163].

A transmitter must transmit with sufficient power to meet system performance objectives while keeping unwanted emissions below required levels.

Systems that employ automatic transmit power control (ATPC) reduce total mean power to a value sufficient to meet the link margin requirements during clear-air conditions. These transmitters increase power occasionally to compensate for excess path loss such as caused by rain fade. If OOB masks are determined as a function of reduced power, then the resultant mask can force attenuation to several orders of magnitude below spurious levels. OOB masks that require attenuation below spurious limits are unnecessarily restrictive.

5. Spurious Emissions for Fixed Service Systems operating above 1 GHz

The spurious emission limits specified in [8], are as follows: in any 1 MHz bandwidth and for fixed service systems operating above 1 GHz, attenuation relative to absolute mean power, P, must be 70 dB or $43 + 10 \log_{10} P$, whichever is less stringent.

When a licensee operates with a payload carrier just inside the assigned frequency block, the modulation process typically produces out-of-band emissions that fall outside the assigned frequency block (Figure 2). For relatively high power transmitters, OOB emissions need to exceed the level normally allowed for spurious emissions.[2]

Spurious and OOB emissions are often studied separately. In this paper, both spurious and OOB emissions are considered to highlight the discontinuity that can exist at the OOB-to-spurious boundary if one studies each region in separate documents.

6. Out of Band Emissions

A mask in the OOB frequency region is typically defined in a way that allows emissions above the spurious level. Administrations have adopted various limits, equations, and algorithms for controlling the shape of the OOB mask as a function of frequency.[3] Most of the methods are a function of mean transmitter power, operating frequency, and necessary bandwidth.

The method of calculating a mask as a function of power works fine for high power transmitters, but for low power transmitters the same algorithm can require unwanted emissions to be far less than spurious emissions levels.

The OOB emission requirements should not require attenuation below the levels allowed for spurious emissions because such a requirement restricts one transmitter while allowing other transmitters to emit higher unwanted emissions. Consider a transmitter site with several transmitters operating in different assigned bands and perhaps in different services. A given frequency might be in the OOB region for one transmitter and in the spurious region for several other transmitters. Interference to a victim receiver is dominated by the largest signal, which could be as high as the spurious level. If a spurious signal is present at the allowed spurious level, effort to restrict the OOB emission to below spurious levels doesn't significantly reduce interference into the victim system.

Services that are assigned using channelized band plans [5] and fully occupy the channel require a two-sided mask around the necessary bandwidth. Services that are assigned using block allocations or partially occupy a channel can safely control unwanted emissions using a one-sided mask on the side of the necessary bandwidth that falls outside of the assigned band.

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[2] For this paper, out of band (OOB) emissions are unwanted emissions that occur at frequencies offset from the center frequency by 50 to 250% of necessary bandwidth, and spurious emissions are all unwanted emissions at frequency offsets greater that 250% of necessary bandwidth. This definition is the same as in [3].

[3] For this paper, the OOB mask from US CFR47, Part 101, Para 101.111a2ii is used as an example. The rule applies in the US for fixed microwave systems operated above 15 GHz.

Figure 3 shows a mask that is typically used for a high power transmitter in a channelized band. The mask is calculated for a 30 MHz necessary bandwidth (line ***gi***) and a mean power of +15 dBW. The center frequency, Fc (line ***gi*** midpoint), has been selected such that the lower portion of the mask is outside an assigned band (line ***BC***). The upper portion of the mask falls inside an assigned band. Lines ***ab*** and ***op*** represent spurious emission limits. Lines ***cd*** and ***lm*** represent the portion of the OOB mask that is limited by an attenuation of 56 dBc . The center frequency of the transmission is set to the lower assigned band + Bn/2 + 0.001% Fc. A relatively high-power transmitter is shown to demonstrate a region where attenuation beyond 56 dB is not required.

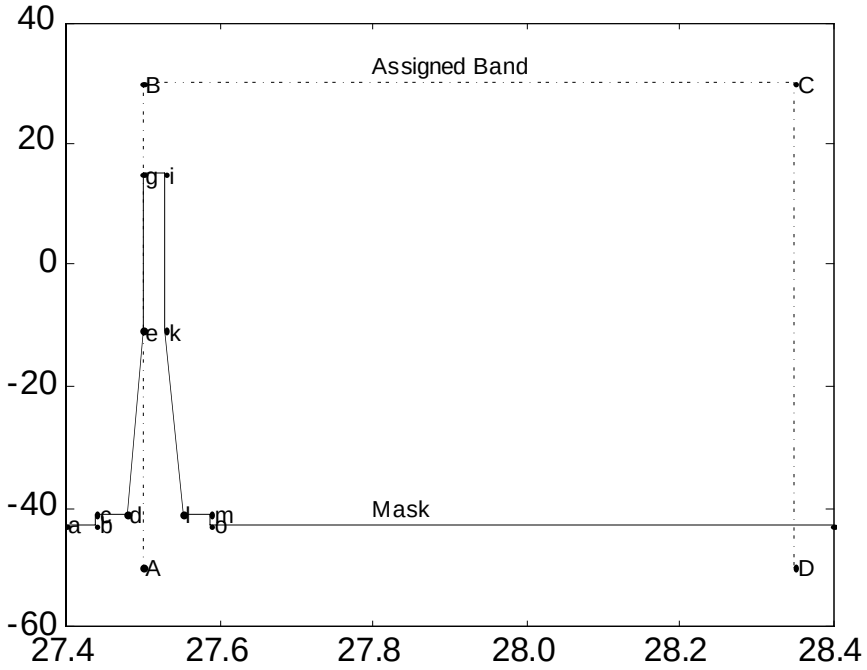

Figure 3, Example unwanted emissions mask typically used for a channelized band and a high power transmitter operated near the assigned band edge. (30 MHz Necessary Bandwidth, 15 dBW Mean Power, 27515.28 MHz Center Frequency, any 1 MHz resolution).

The example of Figure 3 shows that unwanted emissions requirements also apply inside the assigned band.[4] While the portion of the mask outside the assigned band is an appropriate requirement, the portion of the mask inside the assigned band is unnecessary because the unwanted emissions will only produce self-interference to the licensee's system.

[4] The example uses 27.5-28.35 GHz band. Administrations often designate this band for LMDS/LMCS systems and issue area licenses for the entire assigned band.

Figure 4 shows a mask that is typically used for a low power transmitter in a channelized band. The mask is calculated for a 30 MHz necessary bandwidth (line ***gi***) and a mean power of 0 dBW. The center frequency, Fc (line ***gi*** midpoint), has been selected such that the lower portion of the mask is outside an assigned band (line ***BC***). The upper portion of the mask falls inside an assigned band. Lines ***ab*** and ***op*** represent spurious emission limits. Lines ***cd*** and ***km*** represent the portion of the OOB mask that is limited by an attenuation of 56 dBc and is also below the level allowed for spurious emissions. Note that in the out-of-band region, attenuation is below the spurious limits. Transmitters operating at reduced power due to automatic power control exaggerate this example. Note also the requirement for unwanted emission control within the assigned band. This mask is unnecessarily restrictive for block allocated bands.

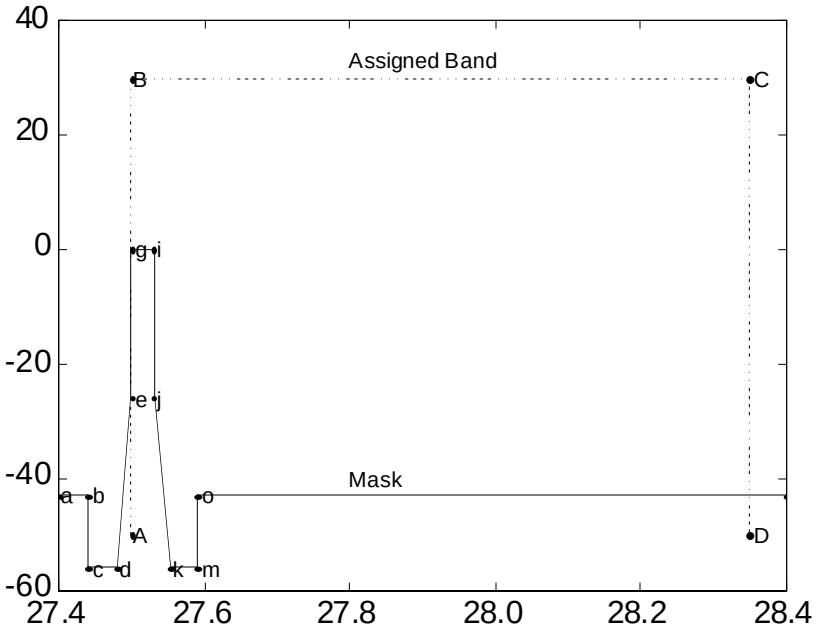

Figure 4, Example emissions mask for a channelized band and a low power transmitter and operating near an assigned band edge. (30 MHz Necessary Bandwidth, 0 dBW Mean Power, 27515.28 MHz Center frequency, any 1 MHz resolution).

7. Proposed Out-of-Band Emission Limits

Given the previous discussion, the following recommendations are made for restricting OOB emissions:

1) OOB emission requirements apply in the 50% to 250% offset region if the frequency is outside the assigned band.

2) No unwanted emission requirements apply within the assigned band other than the same limitations as intended emissions, e.g., maximum authorized power and coordination procedures.
3) Attenuation of OOB emissions to levels below the spurious emission limit is not required.
4) For multiple carrier transmitters, the necessary bandwidth of the modulated carrier or group of modulated carriers nearest the edge of the assigned band is taken to be the occupied bandwidth of the transmitter. The bandwidth of the emission designator also corresponds with the occupied bandwidth. Carriers are assumed to be contiguous in frequency. For transmitters in which multiple carriers or groups of carriers are separated in frequency such that carriers are not contiguous, the necessary bandwidth should be calculated as if the carriers were contiguous. The amplifier bandwidth should not be used unless the 3 dB points of the amplifier fall within the assigned band. The _/2 values above and below a multi-carrier emission may differ and should be adjusted such that the frequencies below the lowest carrier and above the highest carrier are the same frequencies used for the lowest and highest frequency carriers individually.
5) The OOB mask is defined as: "In any 1 MHz at frequencies outside the assigned band, attenuation relative to total mean power should be greater than 11 dB, greater than $11 + 0.4\,(p - 50) + 10\log_{10}(\mathrm{Bn})$, less than 56 dB[5], or power levels limited by 3) above, whichever is the less restrictive (where p is the percent of necessary bandwidth offset from the center frequency of the emission and has a value between 50% and 250% and Bn is the necessary bandwidth)."
6) Appendix A provides example interpretations.

8. Preliminary Draft Revision of ITU-R Recommendation F.1191

After considering the previous discussion, it appears minor adjustments to F.1191-1 are needed. A preliminary draft revision to ITU-R Recommendation F.1191 is contained in Appendix B. The proposed changes are summarized as follows:

in Section 1.3 add,
the definition of "Assigned Band" is restated from the radio regulations.

in Section 2.11, add,
the phrase "falling outside the assigned band," when determining the frequencies in which spurious emissions apply.

[5] See Footnote 3. Attenuation relative to total mean power was used in the example although an equivalent mask can be set in terms of **dBs**. The attenuation minimum, slope, and maximum shown here is the same as that stated in the document from Footnote 3. The mask is suitable for intra-service sharing, which as noted in [1, Annex 4, p. 36], may be more restrict than necessary for inter-service sharing.

Note that F.1191 is currently silent on OOB requirements.

after Section 2.12 add New Considering,
that, the level of out-of-band emissions falling outside of an assigned band, should be no more restrictive than the limit for spurious emissions (see Notes 3, 4, and 7).

add New Note 7,
Unwanted emissions within an assigned band are restricted to no greater than the intentional emissions per the specified conditions of the station license.

Add New Note 8 for considering 2.1,
The stated _/2 value applies to an individual carrier. The _/2 values above and below a multi-carrier emission may differ and should be adjusted such that the frequencies below the lowest carrier and above the highest carrier are the same frequencies used for the lowest and highest frequency carriers individually.

9. Conclusion

This document discusses several issues associated with unwanted emissions and makes a proposal for revising ITU-R Recommendation F.1191. The key points of this paper include: applying unwanted emission limitations only outside the station's assigned band, not requiring OOB limitations below spurious emission levels, and not using amplifier 3 dB bandwidth to determine unwanted emission parameters.

References

1. Chairman T/G 1/5, “Report of the Third Meeting of Task Group 1/5, “ Munich, 9-15 July 1998, Doc 1-5/92, 14 Aug 1998
2. ITU-R Recommendation SM.328-8, “Spectra and Bandwidth of Emissions,” 1994.
3. ITU-R Recommendation SM.329-7, “Spurious Emissions,” 1997.
4. ITU-R Recommendation F.1191-1, “Bandwidth and Unwanted Emissions of Digital Radio-Relay Systems”
5. ITU-R Recommendation F. 746, “Radio Frequency Channel Arrangements for Radio-Relay Systems.”
6. ITU Study Group 9,”Draft Revision of Recommendation ITU-R F.755-1 Point-to-Multipoint systems in the Fixed Service,” SG9/74(rev 2)-E, 21 Oct. 1998.
7. ITU Study Group 9, “Draft Revision of Recommendation ITU-R F1332 Radio Frequency Transport through Optical Fibres,” SG9/48-E, 13 Oct 98.
8. ITU WRC-97 Final Acts, “Spurious Emission Limits for Transmitters installed after 1 January 2003 and for all Transmitters after 1 January 2012,” Appendix S3.

Appendix A
Examples of Out Of Band Emission Masks Relative to an Assigned Band[6]

Figure A-1 shows the mask proposed by Section 7 calculated for a high power transmitter. The mask is based on one RF carrier operating near the lower edge of the assigned band and one RF carrier operating near the upper edge of the assigned band. Both carriers have 30 MHz necessary bandwidth. Lines ***ab*** and ***km*** are spurious emission limits. Lines ***cd*** and ***hj*** are OOB limits in which attenuation beyond 56 dBc is not required. Note there is no mask requirement inside the assigned band.

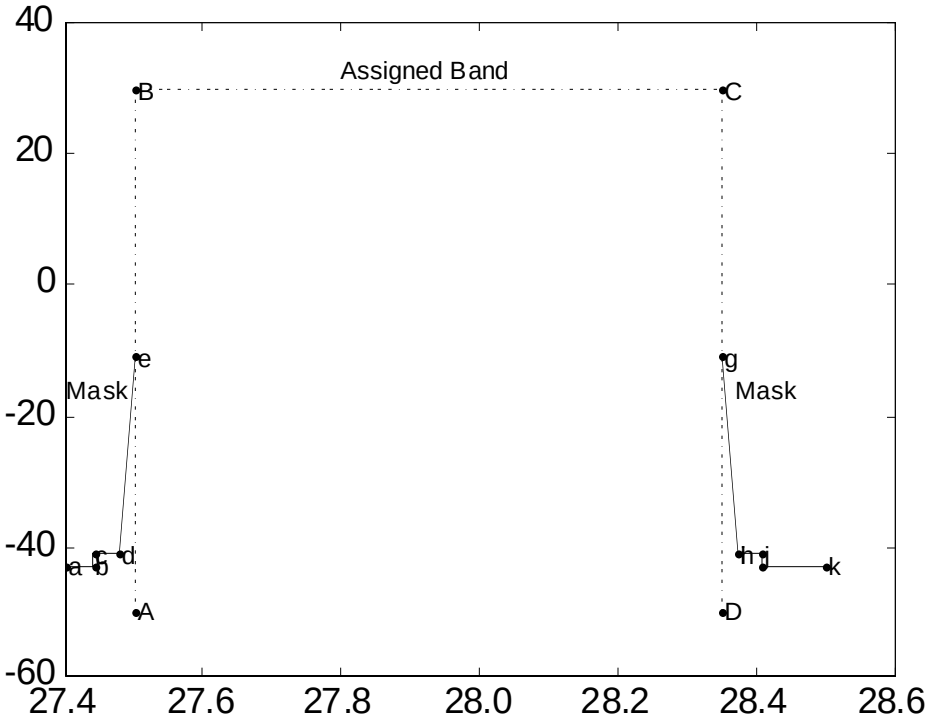

Figure A-1 Unwanted emissions mask as defined in Section 7 for a high-power transmitter with carrier just inside the assigned band. (Two 32 Watts mean power carriers, two 30 MHz bandwidth carriers, 27,515.28 MHz lower carrier center frequency, 28,334.73 MHz upper carrier center frequency, any 1 MHz resolution).

[6] The examples in this Appendix use the 27.5-28.35 GHz band. Administrations often designate this band for LMDS/LMCS systems and issue area licenses for the entire assigned band.

Figure A-2 shows the mask proposed by Section 7 calculated for a low power transmitter. The mask is based on one RF carrier operating near the lower edge of the assigned band and one RF carrier operating near the upper edge of the assigned band. Both carriers have 30 MHz necessary bandwidth. Lines ***ab*** and ***km*** are spurious emission limits. Lines ***bc*** and ***hi*** are OOB limits in which the spurious emission level is used for the mask. Note there is no mask requirement inside the assigned band.

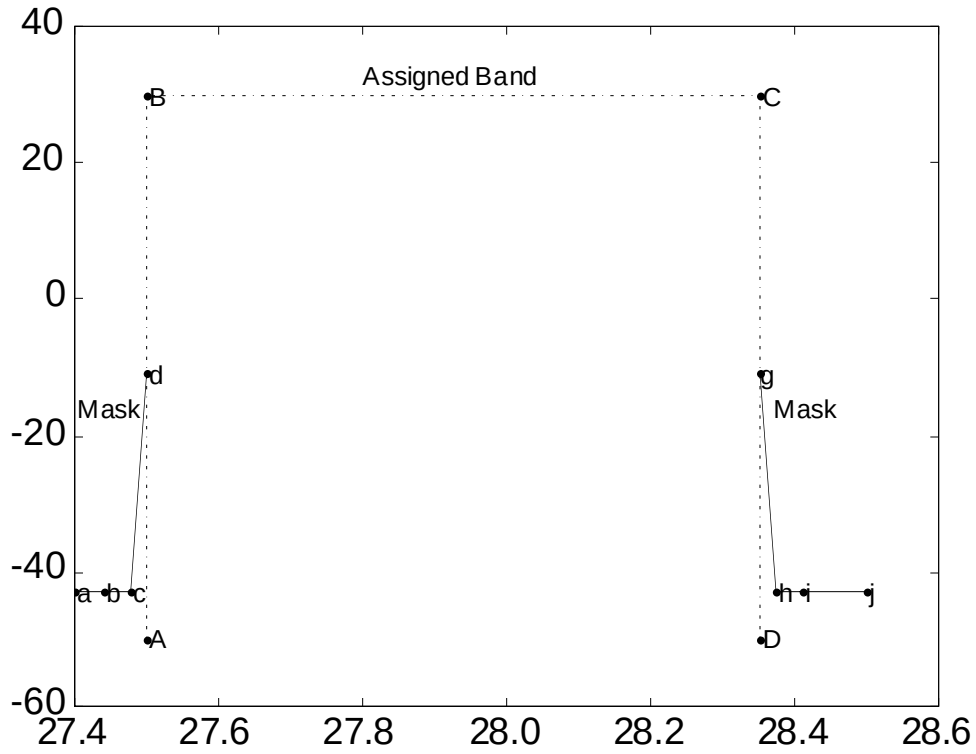

Figure A-2 Unwanted emissions mask as defined in Section 7 for a low-power transmitter with carrier just inside the assigned band. (Two 0 dBW mean power carriers, two 30 MHz bandwidth carriers, 27,515.28 MHz lower carrier center frequency, 28,334.73 MHz upper carrier center frequency, any 1 MHz resolution).

Appendix B,

Preliminary Draft Revision to RECOMMENDATION ITU-R F.1191-1

BANDWIDTHS AND UNWANTED EMISSIONS OF DIGITAL RADIO-RELAY SYSTEMS*

(Question ITU-R 119/9)

(1995-1997)

The ITU Radiocommunication Assembly,

considering

a) that the definitions of necessary and occupied bandwidth and allocated band are reported in Nos. 146, 147 and 17 of the Radio Regulations (RR) respectively;

b) that the definitions of unwanted, out-of-band and spurious emissions are reported in RR Nos. 140, 138 and 139 respectively;

c) that it is necessary to give guidance for the application of these definitions to digital radio-relay systems (DRRS);

d) that it is relatively unlikely that out-of-band emissions from DRRS will cause significant interference into systems operating in adjacent bands, because:

– the power spectrum of a DRRS decays rapidly outside the occupied bandwidth;

– the e.i.r.p. of line-of-sight DRRS is low or medium;

– trans-horizon DRRS employing a high e.i.r.p. are not widely used;

e) that from the viewpoint of interference into other systems sharing the same frequency band, interference due to out-of-band emissions will be, in general, less significant than that due to emissions within the necessary bandwidth;

f) that intra-system interference related problems, which may be caused by unwanted emissions, are normally taken into account by DRRS designers;

g) that bands are allocated to radio-relay fixed services on a primary or co-primary basis, where a radio-frequency channel arrangement has been established by a relevant ITU-R Recommendation or by a National Regulatory Authority;

h) that 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. 343 (S4.5); the transmitters on the radio-frequency channels at the allocated band edges should comply with the general occupied bandwidth compatibility criteria as required by RR No. 147;

j) that at the allocated band edges, radio-frequency bands *ZS*, as defined in Recommendation ITU-R F.746, are given by the relevant ITU-R Recommendations in order to control power spill-over into adjacent allocated bands;

k) that it is not always possible or convenient to make the occupied bandwidth of DRRS smaller than or equal to the bandwidth of the radio-frequency channel provided by

* This Recommendation should be brought to the attention of Radiocommunication Study Group 1 (TG 1/5).

the relevant radio-frequency channel arrangement established for the allocated band by ITU-R or by a National Regulatory Authority;

l) that within the allocated band, coordination between various radio-relay systems used on the basis of a radio-frequency channel arrangement is covered by an efficient concept summarized by Recommendation ITU-R F.746 and by the statistical propagation behaviour reported in Recommendation ITU-R P.530 and Recommendation ITU-R F.1093;

m) that DRRS, with suitable scrambling applied, have in general a transmitted spectral density and unwanted emissions with power peak factors that may be conservatively considered noise-like;

n) that DRRS have unwanted emissions composed of both noise-like and discrete components, made up of out-of-band and spurious emissions, which are not easy to distinguish one from the other;

o) that Recommendation ITU-R SM.329 gives the limits and the reference bandwidth for spurious emissions of all services, including the fixed service;

p) that Recommendation ITU-R SM.329 defines the frequency boundary between spurious and out-of-band emissions as ±250% of the necessary bandwidth; however allowance is given for different definitions, and this frequency boundary 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 systems, the frequency boundary may need to differ from the ±250% factor (see Note 3);

q) that, in fixed service applications, different emissions with different modulation formats and necessary bandwidth may co-exist in the same channel separation; it is therefore convenient, for ease of frequency coordination and for regulatory purposes, to consider the 250% of the constant channel separation as the boundary between out-of-band and spurious emissions, instead of the various different necessary bandwidths of any specific system (see Note 3),

recommends

1 that the following general definitions apply to DRRS:

1.1 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 a specified percentage β/2 of the total mean power of a given emission (RR Article 1, No. 147).

1.2 Necessary bandwidth

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 (RR Article 1, No. 146).

1.3 Allocated frequency band

Allocation (of a frequency band): entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space radiocommunication services or the radioastronomy service under specific conditions. This term shall also be applied to the frequency band concerned (RR Article 1, No. 17). For DRRS the allocated frequency band may be considered as the overall frequency band allocated to the FS on a primary or co-primary basis.

1.3.x Assigned Frequency Band
Authorization given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions. (RR Article 1, No. 19)

1.4 Radio-frequency channel separation

Bandwidth equal to the frequency separation, defined in Recommendation ITU-R F.746, of adjacent channels of the relevant radio-frequency channel arrangement established within the allocated frequency band.

1.5 Guardband

Bandwidth equal to the frequency separation, defined in Recommendation ITU-R F.746 as *ZS*, between the nominal centre frequency of the outermost channel of a radio-frequency channel arrangement and the limit of the allocated band.

1.6 Unwanted emissions

Consist of spurious emissions and out-of-band emissions (RR Article 1, No. 140).
For DRRS an example of a typical scenario is reported in Fig. 2.

1.7 Out-of-band emission

Emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions (RR Article 1, No. 138).

1.8 Spurious emission

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 (RR Article 1, No. 139);

2 that the following specific design objectives and definitions be used for DRRS; an illustration of those objectives and definitions can be found in Fig. 1;

2.1 that, for DRRS, the value of percentage β/2 should be taken as 0.5% (Note 8);

2.2 that, for DRRS, the necessary bandwidth is to be considered to have the same value as the occupied bandwidth;

2.3 that, according to the type of the utilized radio-frequency channel arrangement (see Note 1), the capacity and the modulation format of the transmitted signal, similar DRRS could have a necessary bandwidth which is no more than 20% wider than the radio-frequency channel separation (see Note 1); however, since dissimilar systems operating in the same band could give rise to certain incompatibilities, the relationship between the RF channel separation and the necessary bandwidth requires further study;

2.4 that the determination of occupied bandwidth should be done with a spectrum analyser method described in Recommendation ITU-R SM.328 or, whenever possible, by numerical evaluation or integration of the actual emitted spectrum as reported in Annex 1;

2.5 that when burst transmission is used (e.g. for TDMA DRRS) the evaluation of bandwidths and emissions should be done averaging the power over burst duration;

2.6 that DRRS should use suitable scrambling circuitry in order to maintain all the spectral emissions (both wanted and unwanted) independent from the input data stream;

2.7 that any unwanted emission which falls at frequencies separated from the centre frequency of the emission by less than 250% of the relevant channel separation, where the system is intended to be used, will generally be considered out-of-band emission (see Notes 3 and 4);

2.8 that any unwanted emission which falls at frequencies separated from the centre frequency of the emission by 250% or more of the relevant channel separation, where the system is intended to be used, will generally be considered spurious emission (see Notes 3 and 4);

2.9 that, above and below the limits of the necessary bandwidth, the permissible mean power level of unwanted emission should be less than or equal to 0.5% of the total transmitted mean power taken at the radio antenna port (see Note 2);

2.10 that, from the viewpoint of the international regulations, it is presently not necessary to establish any additional limitation on the spectral shape of unwanted emissions from DRRS;

2.11 that the levels of spurious emissions falling outside of an assigned band of the station, the frequency range to their measurement and the reference bandwidth in which levels are specified should be those defined by ITU-R Recommendation SM.329 as detailed in Annex 2 (see Notes 3, ~~and~~ 5, and 7);

2.12 that, without other specific agreement between administrations sharing the same band edge, the digital radio-relay transmitters operating on the outermost channel frequencies of a radio-frequency channel arrangement should have an occupied bandwidth so that the outermost half of it, when added to the absolute value of the frequency tolerance (see Note 6), results in a bandwidth smaller than or equal to the value of *ZS* as defined in § 1.5.

2.13 that, the level of out-of-band emissions falling outside of an assigned band of the station, should be no more restrictive than for spurious emissions (see Notes 3, 5, and 7).

NOTE 1 – See Recommendation ITU-R F.746 for definitions of alternated, co-channel mode band re-use and interleaved mode band re-use radio-frequency channel arrangements. Channel separation is defined as *XS*/2 for alternated frequency channel arrangements and *XS* for co-channel and interleaved frequency channel arrangements.

NOTE 2 – Due to possible compatibility problems, caution should be exercised when applying this Recommendation to high capacity systems, bands which have dissimilar systems in adjacent channels, and bands which are shared with other services.

NOTE 3 – As Recommendation ITU-R SM.329 allows for boundary values different than ±250%, the following is provisionally recommended for DRRS operating above 1 GHz with channel separation less than 2 MHz:

- that the boundary between the spurious and out-of-band emissions is established as ±500% of the channel separation;
- that the reference bandwidth is 100 kHz in the frequency range between this boundary and ±20 MHz of the nominal centre frequency;

and also for DRRS operating above 1 GHz with transmitter power 20 watts or more and with channel separation between 2 MHz and 14 MHz:

– that the boundary between the spurious and out-of-band emissions is established as ±250% of the channel separation;

– that the reference bandwidth is 100 kHz in the frequency range between this boundary and ±70 MHz of the nominal centre frequency.

NOTE 4 – When the radio-relay system is intended for use in a frequency band where an RF channel arrangement has not been established, the necessary bandwidth should be used, instead of channel separation, in evaluating the 250% boundary.

NOTE 5 – It is recognized that the reference bandwidth of 1 MHz may result in spectral density requirement of up to 24 dB more stringent than with the 4 kHz bandwidth given in the previous version of this Recommendation. Applicability of these new limits to the existing systems will be subject to national regulations or regulations eventually established by World Radiocommunication Conference, (Geneva, 1997) (WRC-97).

NOTE 6 – The precise specification of frequency tolerance values is left to the National Regulatory Authorities.

NOTE 7 – Unwanted emissions within an assigned band are restricted to no greater than intentional emissions per the specified conditions of the station license.

NOTE 8 – The stated _/2 value applies to an individual carrier. The _/2 values above and below a multi-carrier emission may differ and should be adjusted such that the frequencies below the lowest carrier and above the highest carrier are the same frequencies used for the lowest and highest frequency carriers individually.

(The remaining pages of ITU-R Recommendation F.1191-1 not changed and therefore not replicated)