

REPORT ITU-R BT.2075*

**Protection requirements for terrestrial television broadcasting services
in the 620-790 MHz band against potential interference from GSO
and non-GSO broadcasting-satellite systems and networks**

(2006)

Background

The band 620-790 MHz is heavily used in Regions 1, 2 and 3 for the analogue terrestrial television broadcasting service (BS) in many countries. Moreover, digital BS have been developed in a number of countries in this frequency range. The simulcast transmission period is foreseen for 20-25 years to come and requires careful planning to minimize disruption of services. A satellite filing was received by the BR before WRC-03 for the use of the band 620-790 MHz in accordance with former Radio Regulation (RR) No. 5.311, this footnote was modified by WRC-03 clarifying the sharing conditions. Frequency sharing between BSS transmissions and BS in the band 620-790 MHz is stipulated by RR No. 5.311 (as modified by WRC-03), Recommendation 705, and Resolution 545 (WRC-03) of the ITU Radio Regulations. RR No. 5.311 was modified at WRC-03 and further studies, already called for by Recommendation 705, were invited to be urgently carried out on sharing criteria for the protection of terrestrial services in particular television broadcasting services from potential BSS systems operating in the band 620-790 MHz (under WRC-07 agenda item 1.11).

In this regard, ITU-R has undertaken technical studies to identify the protection requirements in terms of the maximum power flux-density (pfd) not to be exceeded at the site of the television receiving station to protect from interference from existing and planned analogue and digital terrestrial BSS in the band 620-790 MHz. This Report provides a methodology for the protection requirements for BS, as well as the results of numerical applications of this methodology for terrestrial analogue and digital (fixed, portable outdoor, portable indoor and mobile) BS.

It is worth noting that RRC-06 adopted Resolution 1 (RRC-06) which resolves to invite WRC-07 to take appropriate and necessary measures to effectively protect the broadcasting Plans adopted by RRC-06 and their subsequent evolution from the GSO-BSS and/or non-GSO BSS networks/systems which were not brought into use prior to 5 July 2003.

It is noted the planning for the band 620-790 MHz arising from the GE-06 plan will not apply to administrations beyond Region 1 and neighbouring countries.

1 Introduction

This Report gives the protection requirements for terrestrial broadcasting services in the 620-790 MHz band against potential interference from broadcasting BSS (GSO, non-GSO) satellite systems. This Report focuses on potential future GSO and non-GSO BSS systems assumed to use

* The administrations of Syria, Lebanon and United Arab Emirates in conformity with the Arab States position in WRC-03, RRC-04 and in RRC-06 continue to object to any consideration of the broadcasting from non-GSO so called "HEO" satellite systems, noting that RR No. 5.311 currently does not allow such broadcasting and the need to protect fully the output Plans and their subsequent evolutions of RRC-06 and hence they are not bound by the content of this Report and will not allow any application in accordance of RR Article 23 for their territories to be covered by any new satellite system of both GSO and non-GSO.

digital transmissions and circular polarization and to operate with elevation angles (in the BSS coverage areas) above 60° only. Annex 1 presents information on these BSS systems which can use both GSO and non-GSO orbits, transmit signals with uniform spectral distribution, which are significantly different from typical analogue BSS emissions. It should be noted the BSS systems considered in this report do not include terrestrial re-transmission facilities. The protection requirements have been derived from published information about the needs for the broadcasting service (CPM Report to WRC-97, ITU Digital Terrestrial Television Handbook, Recommendations ITU-R BT.417, ITU-R BT.419, ITU-R BT.655 and ITU-R BT.1368). However, only those broadcasting systems which are currently using frequencies in the 620-790 MHz band or which are expected to use it in the near future have been included. BSS systems currently introduced include the Russian networks, Statsionar-T and Statsionar-T2, and a proposal for a highly elliptical orbit (HEO) system using a digital modulation and circular antenna polarization.

Digital television services have already commenced operation in a number of countries in this frequency range. It is expected that digital television services will be deployed in an even higher number of countries in the near future and it is expected that analogue television services will continue in many countries for many, possibly 20 to 25 years. Protection of the analogue services is likely to be rather more difficult than is the case for digital services. This is especially true for those countries or parts of countries where the television networks have not yet been fully developed, or in areas where the man-made noise levels are low and where the protection requirements are more stringent simply because the noise and the existing interference levels are low.

In Recommendation 705 (WARC-79) in *considering e)* the following qualification is provided to administrations in calculating minimum field strengths when referencing Recommendation ITU-R BT.417:

- a) that with terrestrial television receiving systems using current technology, the minimum field strength to be protected may in some cases be less than the values included in Recommendation ITU-R BT.417;
- b) that account may have to be taken of ground reflections;
- c) that energy dispersal techniques may reduce the required protection ratio and should be used if shown to be effective.

While Recommendation ITU-R BT.417 Annex 1 states the boundaries of the television service in rural districts having a low population density, where television services are to be provided for a sparsely populated region, in which better receivers and antenna installations are likely to be employed, administrations may find it desirable to establish the appropriate median field strength for which protection against interference is planned.

It should be noted that Recommendation ITU-R BT.417 was last reviewed in 1992 by the ITU-R and may not reflect the performance of today's television receivers and antennas.

Recommendation ITU-R BT.417 gives values obtained from median field-strength investigations at the edge of the coverage area and picture quality assessments for Bands I and III in rural districts of Australia, India and Italy and for Bands IV and V at both rural and urban locations in Italy and the United Kingdom. It may be noted that in Bands IV and V where man-made noise is not generally a problem, the field-strength values quoted for rural areas may also be applied in urban areas.

A key element in planning of terrestrial television services is the consideration given to the point where the television service becomes unwatchable. In some administrations the reception quality of the analogue service is matched to the point where reception of the digital signal would just "fail". In this way the gradual failure characteristic of the analogue signal is matched to the more sudden failure of the digital signal. One administration has adopted in Band V for digital planning minimum median field strength values of 10 dB below the current analogue values.

Because it is certain that terrestrial analogue and digital television services will continue to be deployed over a period of very many years, it is extremely important that the possible existence of satellite-based television transmission and reception in the same band should not in any way interfere with such deployment. In particular, it will be necessary to ensure that if satellite-based services were to become operational, they cannot claim protection of their reception as a reason to prevent the installation of new terrestrial analogue and digital television transmitters or the change of analogue or digital frequency assignments to facilitate the transition period.

The satellite service could be considered to be a 100% of the time co-channel continuous interference source. In Recommendations ITU-R BT.655 and ITU-R BT.1368, the values of protection ratio quoted apply to interference produced by a single source. Except where otherwise stated, the ratios apply to tropospheric, T , interference and correspond closely to a slightly annoying impairment condition. They are considered to be acceptable only if the interference occurs for a small percentage of the time, not precisely defined but generally considered to be between 1% and 10%. For substantially non-fading unwanted signals, it is necessary to provide a higher degree of protection and ratios appropriate to continuous, C , interference should be used. If the latter are not known, then the tropospheric, T , values increased by 10 dB can be applied.

2 Minimum field strengths for the terrestrial television broadcasting service

It should be the minimum field strength value which is the starting point for the discussion. However, this is not usually the case and the minimum median value is taken as a starting point and the resultant discussion becomes rather convoluted as a result. The reason for the shift in the starting point is partly historic and partly convenience.

At the time when the concept and the relevant values were being developed (during the 1950s), it was not known how far equipment development could go and this was especially true for the band 470 to 862 MHz. Certainly the equipment available at that time could not achieve the performance which was implied by the values adopted. Since then performance has continued to improve and nowadays exceeds that expected. Consequently the real minimum field strength is now even less than that used in planning.

It was a matter of convenience to relate all of the planning work to the minimum median field strength values as this:

- provided a fixed reference which did not depend on television receiver development and thus did not change with time;
- provided a link with any coverage measurements which were made;
- provided an approach which simplified the development of international plans and simplified discussions on an international basis.

As a result, it has become current practice to start with the minimum median field strength values and, when necessary, “work backwards” to the minimum field strength values which are the real basis for planning. In fact, it is only very rarely that it is really necessary to do this reverse engineering and this could help to explain why it is always so difficult to do it and to understand it, even though the basics seem to be very simple.

It is interesting to note that adopting the minimum median field strength values as the reference and then deriving the minimum field strength values from them has the result that these minimum field strength values are somewhat higher than they would be if derived directly from the performance of modern television receivers. In other words, the protection requirements placed on other services are lower than they could reasonably be argued to be.

One case where it is necessary to consider the basic numbers and their derivation is where some limiting values must be taken into account. This is particularly true for the case of areas where

interference levels are low and listeners/viewers may be expected to use better than average receiving installations. Such areas exist in most countries, but are particularly relevant to developing countries where transmission networks may not attempt to cover the whole country and viewers are expected to make extra efforts to obtain satisfactory reception quality, for example by using high gain, low noise pre-amplifiers and low loss feeder cable.

However, it must not be assumed that such considerations apply only to developing countries. For example, the broadcasting coverage model applied in one administration seems to concentrate attention on the urban areas and many people living in rural areas need to install special receiving equipment in order to obtain satisfactory reception. In addition, it should be noted that the reference value for digital television reception adopted in another administration seems to include the requirement to use a low noise pre-amplifier wherever necessary. In both of these cases, the impact is to make it necessary to provide protection against interference for signal levels which are lower than those normally adopted in Europe.

3 Protection against interference

Although not directly related to the derivation of minimum field strength and minimum median field strength values, it is necessary to add some words about protection against interference as there is often confusion between the two topics. This is particularly true as the overall treatment in the case of protection of digital television is quite different from that adopted for protection of analogue television.

In some countries the allotment planning for terrestrial television broadcasting services has not included any margin(s) for interference from any other sources other than the adjacent or co-frequency broadcasting service in the band 620-790 MHz. As a result no provisions or co-frequency coordination requirements have been included in the regulatory provisions of many administrations for sharing between broadcasting and other services where broadcasting is the Primary service.

The basis for protection of a wanted signal against interference from some other signal (usually referred to as an “unwanted” signal) is basically very simple and can be considered in terms of a “protection margin”. The protection margin at the input to the receiver is given by:

$$\text{Protection margin} = \text{Wanted signal level} - \text{Impact of interfering signal}$$

The term “impact of interfering signal” takes account of the fact that the affect of the interfering signal is increased by the relevant protection ratio. In practice, it is usually found to be more convenient to deal with field strength values and this then necessitates taking account of the relative gain of the receiving antenna in the direction of the interfering signal. It can be assumed that the feeder cable loss and any frequency dependence either of the receiving antenna or of the feeder cable may be disregarded as they affect the wanted signal and the interfering signal equally – this simplification cannot be made in all interference situations, but applies in the case under consideration here.

In the case where the protection margin is positive, the wanted signal is taken to be protected against interference and is defined to be acceptable. This means that the reception and protection conditions must be clearly defined. This is why, for example, in the case of analogue television, different protection ratios are defined, relevant to the visibility of interference present for different percentages of the time.

Clearly, the limiting value of the wanted signal to be protected is the minimum field strength. It may be less clear what value should be taken for the interfering signal (the latter is usually referred to as the “nuisance” signal if the impact of the receiving antenna and the protection ratio have been taken into account), especially in the case where it is necessary to consider variation of

signal level with location. This is even more true if it is desired to relate protection to median signal levels as these are generally predicted directly.

In the general case, the wanted and interfering signals vary independently and each has its own standard deviation. In such a case, the definition of protection margin needs to be changed to become:

$$\text{Protection margin} = \text{Median wanted signal level} - (\text{Impact of median interfering signal level} + \text{Combined location correction factor})$$

where the combined location correction factor is given by standard statistical theory as:

q * square root (sum of the squares of the two standard deviations), and

q is the statistical multiplying factor relevant to the percentage of locations to be protected.

In practice, it is conventional to protect analogue television reception at only 50% of locations and so there is no requirement to take this additional combined location correction factor into account. In the case of digital television reception, however, this margin must be considered. This is true regardless of the values of the standard deviations of the wanted and interfering signals.

In the case of potential interference arising from a satellite-based signal, the standard deviation of the interfering signal is assumed to be zero and as a result, it becomes possible to simplify the calculations by using only the minimum field strength for the wanted signal, the actual signal level of the interfering signal and location correction factor.

When considering protection requirements for terrestrial fixed reception, antenna discrimination is factored into the calculation. In some cases, BS fixed receiver antennas are sometimes up-tilted in hilly environments to receive TV signals and these tilt angles have been considered to some degree in this Report.

4 Protection criteria for BS reception

With free space propagation conditions for BSS signals, the protection criteria for the BS can be derived from the following equation:

– For analogue BS:

$$E_{\max \text{ int}} = E_{\min} - PR - IM + D_{\text{dir}} + D_{\text{pol}} = \Phi_{\max \text{ int}} + 145.8 \quad (1a)$$

– For digital BS:

$$E_{\max \text{ int}} = E_{\text{med}} + q\sqrt{(\sigma_w^2 + \sigma_i^2)} - PR - IM + D_{\text{dir}} + D_{\text{pol}} = \Phi_{\max \text{ int}} + 145.8 \quad (1b)$$

where:

- $E_{\max \text{ int}}$: maximum allowable BSS field strength at the wanted receiving antenna (dB(μV/m))
- $E_{\min}$: minimum wanted analogue BS field strength at the wanted receiving antenna as per Recommendation ITU-R BT.417-5 $E_{\min} = 62 + 20 \log(f/474)$ (dB(μV/m)). ($f = 700$ MHz)
- E_{med} : median wanted digital BS field strength at the wanted (BS) receiving antenna (dB(μV/m)), and $E_{\text{med}} = E_{\min} - q\sigma_w$
- σ_w : standard deviation of the normal distribution of the wanted signal level (digital BS signals)

- σ_i : standard deviation of the normal distribution of the interfering signal (digital BSS signals). It should be noted that, in the calculations undertaken in this Report, σ_i is assumed to be 0 dB
- q : correction factor obtained from the complementary cumulative inversed normal function $Q(x\%)$, where $x\%$ represents the locations where a certain field strength is present (here, E_{min})
- $q\sigma_w$: “location correction factor” (Recommendation ITU-R P.1546)
- $q\sqrt{(\sigma_w^2 + \sigma_i^2)}$: “propagation correction factor” (Recommendation ITU-R P.1546)
- PR : appropriate BS protection ratio with an additional interservice sharing margin (dB)
- IM : allowance for interservice sharing (dB)
- D_{dir} : BS receiver antenna directivity discrimination with respect to BSS signal (dB)
- D_{pol} : BS receiver polarization discrimination with respect to BSS signal (dB)
- Φ_{max_int} : maximum BSS pfd at receiving antenna in dB(W/m²) per 8 MHz channel (8 MHz being the BS channel bandwidth in the band 620-790 MHz).

This method is in accordance with the method described Recommendation ITU-R BT.1368-6.

The system parameters for the GSO and non GSO BSS considered in this Report are found in § 3.3 of Annex 1.

In other studies in the ITU-R, a clear distinction is made between the allowance for “intra system” noise/interference and “external” or inter system interference, with the allowance for external interference typically significantly far less than the internal allowance. This is reasonable because intra-system interference can be taken into account as part of fundamental BS network planning and so is under the control of the BS, whereas other than by means of regulatory protection, no control can be exercised over external interference and any external interference will erode the margin set aside for intra system interference.

In other contexts where systems are homogeneous (e.g. between two point-to-point links in the fixed service) an I/N requirement of –6 dB (or sometimes –10 dB) is commonly adopted, however where non-homogeneous services or intraservice interference is involved (and where the spectrum regulator implicitly has less ability to separately manage interference between services) an I/N of –10 dB (or more) may be adopted. An additional “interservice interference margin” of 10 dB has therefore been added to the BS-BS protection ratio values currently included in Table 1 and Tables 3 to 7. A figure of –9.1 dB has been used in Table 2.

It should be noted that, for the case of the protection of analogue reception, the use of minimum median field strength values from Recommendation ITU-R BT.417-5 have been used. Annex 1 to Recommendation ITU-R BT.417-5 provides minimum median field strength values for which protection against interference may be planned for sparsely populated regions. The minimum median field strength specified for such areas is 6 dB below the minimum median field strength specified for Band V in *recommends* 1 of Recommendation ITU-R BT.417-5. This 6 dB factor has been used in differentiating the minimum median field-strength values used for analogue BS nominal coverage area and fringe coverage area cases.

5 Definition for the fixed, portable and mobile reception

The definition for the fixed, portable and mobile reception give some bases to the understanding of the class of service referred to in the Report. It is considered important to have a common understanding about the same type of reception/service in the different regions and to clearly

stipulate the correspondence of each type of reception. It is considered useful and important to define each of them and avoid misunderstanding when comparing different implementations, for example portable which is a stationary reception and not a mobile reception type or a hand held¹ reception type.

5.1 Fixed reception

Fixed reception is defined as reception where a directional receiving antenna mounted at roof level is used.

It is assumed that near-optimal reception conditions (within a relatively small volume on the roof) are found when the antenna is installed.

In calculating the field strength for fixed antenna reception, a receiving antenna height of 10 m above ground level is considered to be representative for the broadcasting service. Other heights might be used for other services.

5.2 Portable reception

Portable reception is defined as:

- Class A (outdoor), which means reception where a portable receiver with an attached or built-in antenna is used outdoors at no less than 1.5 m above ground level;
- Class B (ground floor, indoor), which means reception where a portable receiver with an attached or built-in antenna is used indoors at no less than 1.5 m above floor level in rooms with the following characteristics:
 - on the ground floor;
 - with a window in an external wall.

Portable indoor reception on the higher floors will be regarded as Class B reception with signal level corrections applied, although indoor ground floor reception is likely to be the most common case.

In both Classes A and B, it is assumed that:

- optimal receiving conditions will be found by moving the antenna up to 0.5 m in any direction;
- the portable receiver is not moved during reception and large objects near the receiver are also not moved;
- extreme cases, such as reception in completely shielded rooms, are disregarded.

5.3 Mobile reception

Mobile reception is defined as reception by a receiver in motion with an antenna situated at no less than 1.5 m above ground level. This could for example be a car receiver or handheld equipment.

The dominant factor with regard to local reception effects is thought to be due to fading in a Rayleigh channel. Fade margins are intended to offset these effects. Fade margins depend on the frequency and the velocity.

¹ Handheld devices are personal wireless devices, normally of a very small size similar to that of a mobile phone or personal digital assistant (PDA), with the capability of receiving audiovisual streams and data service, and often with facilities for bidirectional voice/data communication.

6 Assumptions made for this Report

a) *Protection requirements for terrestrial analogue reception in the 620-790 MHz band*

- It is assumed the values in Recommendation ITU-R BT.419 can be used in both horizontal and vertical planes.
- It is assumed that potential GSO and non-GSO BSS systems and networks under consideration in this Report would benefit from having service areas served with high elevation angles.
- It is also assumed that BS signals are linearly polarized, and in the band 620-790 MHz the potential GSO and non-GSO BSS systems are circularly polarized.
- It has been assumed that the potential interfering GSO and non-GSO BSS satellite signal will use digital modulation and in that case it can be considered as a white-noise like signal, and Recommendation ITU-R BT.1368 is taken as a basis to derive the relevant protection ratios.
- It is assumed that the maximum degradation in BS C/N margin that can be tolerated, due to co-frequency sharing with other services including the potential BSS, is 0.5 dB of the available margin.
- The potential GSO and non-GSO BSS systems and networks under consideration in this Report do not have any return channel or terrestrial retransmission requirements.

b) *Protection requirements for terrestrial digital fixed reception in the 620-790 MHz band*

- It is assumed that Recommendation ITU-R BT.419 can be used in both horizontal and vertical planes.
- As a receiving antenna is situated at around 10 m above the ground the most important contribution to the received signal comes from the line-of-sight signal from the satellite. Although there may exist shadowing and multipath contributions, they are believed to be insignificant. Therefore, the satellite signal standard deviation, σ_s , is assumed to be 0 dB and the propagation correction factor, $q\sqrt{\sigma_w^2 + \sigma_i^2}$, equals the location correction factor, $q\sigma_w$.
- It is assumed that potential BSS systems under consideration in this Report would benefit from having service areas served with high elevation angles.
- It is also assumed that BS signals are linearly polarized, and BSS systems circularly polarized. The receiver antenna polarization discrimination is determined by the low elevation angle case.
- It is assumed that the maximum degradation in BS C/N margin that can be tolerated, due to co-frequency sharing with other services including BSS, is 0.5 dB of the available margin.
- The potential GSO and non-GSO BSS systems and networks under consideration in this Report do not have any return channel or terrestrial retransmission requirements.

7 Protection requirements for terrestrial analogue reception in the 620-790 MHz band

The maximum allowable interfering field strength for angles of arrival from the potential BSS for the terrestrial analogue television broadcasting service in the 620-790 MHz band is listed in Table 1.

In some administrations planning consideration is given to the minimum field strengths required for the terrestrial television broadcasting service in fringe coverage areas. This is a worst case example for single entry pfd's.

TABLE 1
Protection requirements for analogue service (fixed reception)

	BS nominal coverage areas (Note 1)		BS fringe coverage areas (Note 1)	
	$\delta \leq 20^\circ + x^{\text{oa}}$ (Note 2)	$\delta \geq 60^\circ + x^{\text{o}}$ (Note 2)	$\delta \leq 20^\circ$	$\delta \geq 60^\circ$
Nominal bandwidth (MHz)	8 ^b	8	8	8
Minimum median field strength (dB($\mu\text{V/m}$)) (Note 1)	65.4 ^c	65.4	59.4 ^d	59.4
Derived power flux-density (dB(W/m ²)) (Note 3)	-80.4	-80.4	-86.4	-86.4
Receiving antenna directivity discrimination (dB) (Note 4)	0	16	0	16
Receiving antenna polarization discrimination (dB) (Note 5)	1.25	0	1.25	0
Required protection ratio (dB) (Note 6)	44	44	44	44
Allowance for interservice interference (Note 6bis) (dB)	10	10	10	10
Maximum interfering single entry pfd (dB(W/m ²)) (Note 7)	-133.15	-118.4	-139.15	-124.4
Maximum interfering field strength (dB($\mu\text{V/m}$)) (Note 7)	12.65	27.4	6.65	21.4

^a For values between $20^\circ + x^\circ$ and $60^\circ + x^\circ$ a mask may be derived by linear interpolation.

^b The channel bandwidth of 8 MHz is listed and it should be noted that some administrations use 6 MHz and 7 MHz channelling.

^c Derived from the median figures as specified in Tables 1 and 2 of Recommendation ITU-R BT.417 with a 6 dB margin compared to the minimum field strength values given in this Recommendation.

^d In some administrations lower minimum field strength levels are planned.

NOTE 1 – *BS nominal coverage areas* are the areas with typical man-made noise levels. The minimum field strength to be protected at the edge of the coverage area is derived from Recommendation ITU-R BT.417-5. Current BS planning in many administrations has been undertaken in total isolation of interference margins for a source of interference other than adjacent and co-frequency BS.

BS fringe coverage areas are areas where the television broadcasting networks are relatively sparse and viewers are expected to use high gain antennas and low noise preamplifiers. In some fringe areas interference from man-made interference is very low. Therefore, the value of minimum field strength to be protected given for 582-960 MHz band is often reduced by 6 dB. In such cases the derived pfd and maximum interfering signals must also be reduced by 6 dB. Such values are expected to apply in a relatively large number of developing countries, in particular, and in rural areas in other countries (see Annex 1 to Recommendation ITU-R BT.417).

NOTE 2 – The receiving antenna discrimination is obtained using directly Recommendation ITU-R BT.419. Investigations have shown that this assumption does not remain valid in hilly environments. Annex 2 concludes that a representative average tilt angle of $x^\circ = 10^\circ$ can be used although one Administration stated that a representative tilt angle of $x^\circ = 15^\circ$ is more appropriate to cover this phenomenon.

NOTE 3 – The conversion between pfd (ϕ) and minimum field strength (E) is by means of the formula $E = \phi + 145.8$, where E is in dB($\mu\text{V/m}$) and ϕ is in dB(W/m²).

NOTE 4 – Terrestrial television applications use directional antennas, but these are very often horizontally polarized and have relatively wide beams in the vertical plane, thus there is no discrimination against interfering signals originating in a satellite for $\delta \leq 20^\circ + x^\circ$. It is assumed that Recommendation ITU-R BT.419 can be used in both horizontal and vertical planes. It has been also assumed that linear interpolation may be used for values of δ between $20^\circ + x^\circ$ and $60^\circ + x^\circ$.

NOTE 5 – It is assumed that potential GSO and non-GSO BSS systems and networks under consideration in this Report would benefit from having service areas served with high elevation angles. It is also assumed that BS signals are linearly polarized, and potential GSO and non-GSO BSS systems circularly polarized. As a consequence, polarization discrimination situation will experience two situations:

- for angles of arrival $\geq 60^\circ + x^\circ$, the potential BSS interferer transmits in its main beam, and the BS victim receives in its side and back lobes: in this case, Recommendation ITU-R BT.419 indicates that polarization discrimination is already taken into account;
- for angles of arrival between $20^\circ + x^\circ$ and 60° a mask may be derived by linear interpolation;
- for angles of arrival $\leq 20^\circ + x^\circ$, the victim BS receives in its main lobe, and the potential BSS interferer transmits in the worst case in its first sidelobe, resulting in a BSS/BS polarization discrimination of 1.25 dB.

NOTE 6 – It has been assumed that the potential interfering non-GSO BSS satellite signal will use digital modulation and in that case it can be considered as a white-noise like signal, and Recommendation ITU-R BT.1368 is taken as a basis to derive the relevant protection ratios. This Recommendation contains a 41 dB protection ratio (PR) value for the case of continuous interference for intra service planning, although for the purpose of this Recommendation the term “continuous” means 50% of time. As interference is present for 100% of the time, in the case for satellite based interfering signals, 3 dB has been added to the relevant PR values given in Recommendation ITU-R BT.1368.

NOTE 6bis – Beyond the PR required for BS-BS intraservice interference that is built into the PRs in Recommendation ITU-R BT.1368, interference contributions arising from interservice sharing (between the BS and interference from other services including potential BSS) need to be 10 dB lower to ensure the degradation in C/N margin is limited to approximately 0.5 dB of the available margin.

NOTE 7 – The quoted pfd is the single entry value tolerable within the nominal bandwidth of a television channel. If there are multiple interfering satellite signals in the same pass band, their interfering pfd must be combined. The study contained in Section 9 of Annex 1 can be used to determine an allowance for the aggregate pfd case if required.

8 Protection requirements for terrestrial digital fixed reception in the 620-790 MHz band

Tables 2, 3 and 4 address the respective protection requirements for fixed reception of the digital television broadcasting systems; System A (ATSC), System B (DVB-T) and System C (ISDB-T). The system characteristics and protection requirements can be found in Recommendations ITU-R BT.1306 and ITU-R BT.1368 respectively. Further information on these systems can be found in the ITU Digital Terrestrial Television Handbook.

While a nominal bandwidth has been specified in the following Tables for representative channelling it should be noted that many administrations use the other channelling within their terrestrial television broadcasting.

TABLE 2

Protection requirements for digital System A (ATSC) (fixed reception)

	$\delta \leq 20^\circ$	$\delta \geq 60^\circ$
Nominal bandwidth (MHz)	6	6
Minimum field strength (dB(μ V/m)) (Note 10)	39 ⁽¹⁾	39
Derived pfd (dB(W/m ²)) (Note 4)	-106.8	-106.8
Receiver antenna directivity (dB) (Note 5)	0	16
Receiver antenna polarization (dB) (Note 7)	1.25	0
Required PR (dB)	19.5	19.5
Allowance for interservice interference (Note 8bis) (dB)	9.1	9.1
Maximum interfering single entry pfd (dB(W/m ²)) (Note 10)	-134.15	-119.4
Maximum interfering field strength (dB(μ V/m))	11.65	26.4

⁽¹⁾ These are indicative values for minimum field strength for digital System A.

TABLE 3

Protection requirements for digital System B (DVB-T) (fixed reception)

	16-QAM, Code rate 2/3		64-QAM, Code rate 2/3	
	$\delta \leq 20^\circ + x^\circ$ (Note 1)	$\delta \geq 60^\circ + x^\circ$ (Note 1)	$\delta \leq 20^\circ + x^\circ$ (Note 1)	$\delta \geq 60^\circ + x^\circ$ (Note 1)
Nominal bandwidth (MHz)	8	8	8	8
Required C/N ratio (dB) (Note 2)	14.6	14.6	20.1	20.1
Minimum field strength (dB(μ V/m)) (Note 3)	41.4	41.4	46.9	46.9
Location correction factor (dB) (Note 6.1)	-9	-9	-9	-9
Minimum median field strength (dB(μ V/m))	50.4	50.4	55.9	55.9
Derived median pfd (dB(W/m ²)) (Note 4)	-95.4	-95.4	-89.9	-89.9
Receiving antenna directivity discrimination (dB) (Note 5)	0	16	0	16
Receiving antenna polarization discrimination (dB) (Note 7)	1.25	0	1.25	0
Required PR (dB) (Note 8)	14.6	14.6	20.1	20.1
Allowance for interservice interference (Note 8ter) (dB)	10	10	10	10
Propagation correction factor (dB) (Note 6.2)	-9	-9	-9	-9
Maximum interfering single entry pfd (dB(W/m ²)) (Notes 9 and 11)	-127.75	-113.0	-127.75	-113.0
Maximum interfering field strength (dB(μ V/m)) (Notes 9 and 11)	18.05	32.8	18.05	32.8

TABLE 4

Protection requirements for digital System C (ISDB-T) (fixed reception)

	64-QAM, Code rate 3/4					
	$\delta \leq 20^\circ + x^\circ$ (Note 1)	$\delta \geq 60^\circ + x^\circ$ (Note 1)	$\delta \leq 20^\circ + x^\circ$ (Note 1)	$\delta \geq 60^\circ + x^\circ$ (Note 1)	$\delta \leq 20^\circ + x^\circ$ (Note 1)	$\delta \geq 60^\circ + x^\circ$ (Note 1)
Nominal bandwidth (MHz)	6	6	7	7	8	8
Minimum field strength (dB(μ V/m)) (Note 13)	45.5	45.5	46.2	46.2	46.7	46.7
Location and time-correction factor (dB) (Note 12)	−9	−9	−9	−9	−9	−9
Minimum median field strength (dB(μ V/m))	54.5	54.5	55.2	55.2	55.7	55.7
Derived median pfd (dB(W/m ²)) (Note 4)	−91.3	−91.3	−90.6	−90.6	−90.1	−90.1
Receiving antenna directivity discrimination (dB) (Note 5)	0	16	0	16	0	16
Receiving antenna polarization discrimination (dB) (Note 7)	1.25	0	1.25	0	1.25	0
Required PR (dB) (Note 8)	21	21	21	21	21	21
Allowance for interservice interference (Note 8ter) (dB)	10	10	10	10	10	10
Propagation correction factor (dB) (Note 12)	−9	−9	−9	−9	−9	−9
Maximum interfering single entry pfd (dB(W/m ²)) (Note 9)	−130.05	−115.3	−129.35	−114.6	−128.85	−114.1
Maximum interfering field strength (dB(μ V/m)) (Note 9)	15.75	30.5	16.45	31.2	16.95	31.7

NOTE 1 (Tables 3, 4) – The receiving antenna discrimination is obtained using Recommendation ITU-R BT.419. Investigations have shown that this assumption does not remain valid in hilly environments. Annex 2 concludes that a representative average tilt angle of $x^\circ = 10^\circ$ can be used although some Administrations stated that a representative tilt angle of $x^\circ = 15^\circ$ or some other value may be more appropriate to cover this phenomenon.

NOTE 2 (Table 3) – The required C/N values are stated in the ITU Digital Terrestrial Television Handbook for fixed and portable digital television reception (Rice and Rayleigh channels, respectively). In fact, it is not really critical which values of C/N ratio are used here as the same value must be used as the PR in a later part of the calculations.

NOTE 3 (Table 3) – The minimum field-strength values for digital terrestrial television have been calculated for the frequency of 700 MHz as per methodology in Recommendation ITU-R BT.1368-5. The usage of this voltage method stipulates that the value for the maximum interfering field strength does not depend on the variant of the digital terrestrial broadcasting systems. However, in the case of DVB-T, two variants are listed in the Table 3 for demonstration purpose.

NOTE 4 (Tables 2, 3, 4) – The conversion between pfd (ϕ) and minimum field strength (E) is by means of the formula $E = \phi + 145.8$ where E is in dB(μ V/m) and ϕ is in dB(W/m²).

NOTE 5 (Tables 2, 3, 4) – Terrestrial analogue and digital television applications for fixed reception use directional antennas, but these are very often horizontally polarized and have relatively wide beams in the vertical plane, thus there is no discrimination against interfering signals originating in a satellite for $\delta \leq 20^\circ + x$. It is assumed that Recommendation ITU-R BT.419-3 can be used in both horizontal and vertical planes. It has been assumed that linear interpolation may be used for values of δ between $20^\circ + x^\circ$ and $60^\circ + x^\circ$.

NOTE 6.1 (Table 3) – As described in Recommendation ITU-R P.1546, broadband digital DVB-T signals follow a log-normal law distribution, with a standard deviation, σ_w , of 5.5 dB. In order to ensure a coverage of 95% of locations, q becomes $Q(95\%) = -1.64$. The location correction factor for the wanted signal equals $q\sigma_w = -1.64 \times 5.5 = -9$ dB.

NOTE 6.2 (Table 3) – As described in Recommendation ITU-R P.1546, broadband digital DVB-T signals follow a log-normal law distribution, with a standard deviation of 5.5 dB. In order to ensure a coverage of 95% of locations, q becomes $Q(95\%) = -1.64$. As a receiving antenna is situated at around 10 m above the ground the most important contribution to the received signal comes from the line-of-sight signal from the satellite. Although there may exist shadowing and multipath contributions, they are believed to be insignificant. Therefore, the satellite signal standard deviation, σ_i , is assumed to be 0 dB and, in this case, the propagation correction factor, $q\sqrt{\sigma_w^2 + \sigma_i^2}$, thus equals $q\sigma_w = -9$ dB.

NOTE 7 (Tables 2, 3, 4) – It is assumed that potential BSS systems under consideration in this Report would benefit from having service areas served with high elevation angles. It is also assumed that BS signals are linearly polarized, and potential BSS systems circularly polarized. As a consequence, polarization discrimination situation will experience two situations:

- for angles of arrival $\geq 60^\circ + x^\circ$, the potential BSS interferer transmits in its main beam, and the BS victim receives in its side and back lobes: in this case, Recommendation ITU-R BT.419 indicates that polarization discrimination is already taken into account;
- for angles of arrival between $20^\circ + x^\circ$ and $60^\circ + x^\circ$ a mask may be derived by linear interpolation;
- for angles of arrival $\leq 20^\circ + x^\circ$, the victim BS receives in its main lobe, and the potential BSS interferer transmits in the worst case in its first sidelobe, resulting in a BSS/BS polarization discrimination of 1.25 (refer Annex 1).

NOTE 8 (Tables 3, 4) – The PR for terrestrial digital signals has been taken from the Recommendation ITU-R BT.1368, corresponding to the PR ratio for co-channel interference from a digital signal to the digital signal. Because of the very rapid transition to failure for digital signals, there is no need to distinguish between different percentages of time. The same PR values apply to all percentages of time.

NOTE 8bis (Table 2) – Beyond the PR required for BS-BS intraservice interference that is built into the PRs in Recommendation ITU-R BT.1368, interference contributions arising from interservice sharing (between the BS and interference from other services including potential BSS) need to be 9.1 dB lower to ensure the degradation in C/N margin is limited to 0.5 dB of the available margin.

NOTE 8ter (Tables 3, 4) – Beyond the PR required for BS-BS intraservice interference that is built into the PRs in Recommendation ITU-R BT.1368, interference contributions arising from interservice sharing (between the BS and interference from other services including potential BSS) need to be 10 dB lower to ensure the degradation in C/N margin is limited to approximately 0.5 dB of the available margin.

NOTE 9 (Table 2, 3, 4) – The quoted pfd is the single entry value tolerable within the nominal bandwidth of a television channel. If there are multiple interfering satellite signals in the same passband, their interfering pfd's must be combined. The study contained in § 9 of Annex 1 can be used to determine an allowance for the aggregate pfd case if required.

NOTE 10 (Table 2) – The broadcasting coverage model applied in one administration provides attention to urban areas. However, many people living in the rural areas need to install special receiving equipment in order to obtain satisfactory reception. Furthermore, it should be noted that the planning of digital television services in another administration is based on the use of low noise amplifiers in rural areas. In both of these cases, it is necessary to provide protection against interference for field strength levels that are lower than those normally adopted elsewhere.