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North American Broadcasters Association (NABA)

PRELIMINARY DRAFT NEW REPORT ITU-R BS.[PROTECT-WIRED]

Protection requirements of broadcasting systems against interference from radiation caused by wired telecommunication systems

The North American Broadcasters Association (NABA, www.nabanet.com) is an association of broadcasters in Canada, Mexico, and the United States, and the NABA Technical Committee is its standing technical body. NABA is thus in a position to present the technical viewpoints of the most authoritative association of professional North American Broadcasters in television and sound programme production, post-production, and distribution for terrestrial, satellite, and cable broadcasting.

NABA is a Sector Member of ITU-R and a long-time participant in ITU-R Study Groups, Working Parties, Task Groups, Rapporteur Groups, etc. NABA numbers among its members Chairmen, Vice-Chairmen and members of the above groups. NABA also participates widely in the ITU work on radio, television and multimedia services and has a strong interest in spectrum management studies including spectrum engineering techniques, spectrum management fundamentals, spectrum monitoring, and inter-service sharing, interference and compatibility.

NABA notes that while satisfactory progress has been already made with some ITU-R Recommendations on the subject of interference, an adequate criterion for protection of the broadcasting services from harmful interference caused by radiation from wired telecommunication systems is needed. NABA notes further that Working Party 6A has addressed in detail the issue of emissions from wired telecommunication systems in the Preliminary Draft New Report attached as Annex 13 to the Working Party 6A Chairman's Report (Document 6A/196). NABA also notes that Study Group 1 at it September 2009 meeting has approved two Reports entitled "Report ITU-R SM.[PLT] - Impact of power line telecommunication systems on radiocommunication systems operating in the LF, MF, HF and VHF bands below 80 MHz" and "Report ITU-R SM.[PLT-MEASUREMENT] - Measurement methods for power line high data rate telecommunication systems" (Documents 1/67 and 1/74, respectively). NABA has noticed that the approved Document 1/67 incorporates the information found in the Annexes (Part 2) of the Working Party 6A Report (Annex 13 to Document 6A/196). Consequently, the Annexes need not duplicate this information.

NABA believes that the main body of the Report does provide valuable information concerning not only the impact of wired telecommunication systems on the broadcasting service but also establishes the basis for the protection of the broadcasting service. In this context, NABA offers in the Annex some improvements to the text of the Report for the consideration of Working Party 6A in view of its possible submission to Study Group 6 as a draft new Report.

Annex

[PRELIMINARY] DRAFT NEW REPORT ITU-R BS.[PROTECT-WIRED]

Protection requirements of broadcasting systems against interference from radiation caused by wired telecommunication systems

(Question ITU-R 32/6)

Summary

This Report addresses the impact of Power Line Telecommunication (PLT) Systems on the broadcasting services operating in the bands below 80 MHz and the criteria required for protection.

Increasing use is being made of mains electrical wiring for the transmission of wideband data. Mains electrical wiring is, typically, neither designed nor engineered for the transmission of wide bandwidth data and incidental radiation from the wiring is a consequence. PLT systems usually operate in the frequency bands below 80 MHz and so the resulting radiation is also in these bands. Any broadcast receiver operated in the vicinity of a mains conductor carrying PLT will perceive this radiation as an increase in the noise floor and inhibit the receiver’s ability to resolve low level signals.

1 Introduction

For the purpose of this document the following terms are taken to have the attached meanings:

Electrical infrastructure wiring – This means the whole of the electrical distribution wiring from the generating station through to power sockets, light fittings, switches, etc., and the individual appliances, lamps, etc. connected directly to it. Importantly, since the primary focus of this document is the effects found inside buildings, the electrical infrastructure wiring includes household and/or office and other building wiring systems, AC outlets and all spurs or branches to light fittings, ceiling outlets, etc.

PLT (Power Line Telecommunication) system – The communications system which uses the electrical infrastructure wiring, or parts of it, to transfer high-frequency data signals from place to place. The PLT system is typically superimposed on existing electrical infrastructure wiring.
In certain countries the term BPL (Broadband Over Powerline) is used instead of PLT.

The output power and antenna characteristics of broadcast transmitting facilities are set to cover specific geographic areas which are, in turn, defined in various national, regional and international plans and/or regulations. One factor which affects the service area of a transmission facility is the level of inherent, radio noise encountered on the ground. The wanted signal strength must exceed the strength of the noise by a sufficiently large margin to offer adequate reception quality.
The adequacy of the service quality and the signal levels necessary to achieve this are laid down in various existing ITU-R Recommendations and in the proceedings of the planning conferences. This information forms much of the basis of this Report.

PLT systems have the potential to increase the level of ambient noise at locations where they operate. Clearly this will impact on the performance potential of any broadcast receiver operating at that location.

The purpose of this document is to:

– explain how the performance of a broadcast receiver is limited by the level of ambient noise, including noise from PLT systems; to quantify the noise environment in which a broadcast receiver can operate satisfactorily;

– provide the levels of ambient noise, including noise generated by PLT systems that a broadcast receiver can tolerate by collecting and collating data from existing ITU-R Recommendations, etc.;

– complement existing Recommendation(s) dealing with the relevant protection requirements for broadcasting systems.

While recognizing that any increase in the ambient noise level will affect all services operating in the relevant frequency band, this Report will restrict itself to the impact on the broadcasting service only. This Report is supplemented with data from analyses, laboratory tests, field tests, and various measurement programmes that can be found in Reports ITU-R SM.[1/67] and SM.[1/74].

2 Broadcasting

Broadcasting activity takes place in a number of frequency bands below 80 MHz. Interference from PLT systems is likely to be encountered in the LF, MF and HF bands which are listed in Section 8.1. In practice, and under Article 4.4 or the Radio Regulations, some broadcasting takes place outside the bands specifically allocated to the Broadcasting Service. The table of frequencies in Section 8.1 however, simply reflects the frequency allocation table in Article 5 of the Radio Regulations. These bands are predominantly used for analogue AM radio services and this has been the case for many years. In addition, VHF Band 1 (47 MHz to 72 MHz) is used in some parts of the world for analogue television services (see Article 5 of the Radio Regulations).

Over the last ten or more years various digital radio modulation formats have been developed for use in the LF, MF and HF bands. Typically, digital modulation formats have various modes of operation some of which are specifically designed to maintain services in difficult propagation conditions at the expense of audio quality. This means that in situations where audio quality is not a prime concern, there is potential for serving wider audiences and to use lower transmitter powers. In addition, AM radio was conceived to operate with “self-powered” receivers and so is quite inefficient in its use of transmitter power. Modern (digital) modulation formats only need to transmit (useful) information-carrying power. This in turn means that the usable signal strength of digital transmissions is commensurately lower but does not automatically result in enhanced robustness to noise and interference.

(Currently under development are several digital systems which offer the technical possibility to mount radio transmission in bands between 47 MHz and 80 MHz).

3 Power Line Telecommunications (PLT)

Power Line Transmission (PLT) is a technology that utilizes electrical power lines for the distribution of high data rate telecommunication services. PLT systems can conveniently be divided into two distinct categories:

– access PLT which covers the “last mile” between the electricity supply sub-station and the user; an alternative means of providing access to telecommunications services;

- indoor PLT which aims to distribute data (coming for example from Access PLT or DSL) within building via the electricity sockets.

Electrical infrastructure wiring is not designed as a high data rate transmission medium.
The electrical balance between the conductors in not a design consideration when planning such wiring and the existence of light fittings, switches, spurs, junction boxes etc. means that installing a balanced system would anyway be prohibitively difficult.

The conservation of energy law of physics means that that portion of the RF energy employed in PLT systems which is not intercepted by the load or dissipated as heat through power line resistive losses will be radiated from the transmission lines and the distribution wiring on which the RF signals are imposed. PLT systems will inevitably radiate a considerable portion of the energy contained in the RF signals imposed on them because the power lines used for the distribution of mains electricity are:

- not shielded;
- not balanced;
- incapable of being configured to maintain an unvarying characteristic impedance value at RF along their length;
- incapable of being terminated correctly at RF.

For these reasons there is a high probability that the electrical infrastructure wiring will operate as a transmitting antenna at the operating frequencies of PLT systems. The existence of a PLT signal on the mains wiring will not only impact the electrical activity on the wiring itself, but also the RF (noise) environment encountered by any radiocommunication receiver operated in the vicinity of the PLT wiring. The receiver will inevitably perceive this as an interfering signal which will affect its ability to receive any wanted radiocommunication signal. While the exact nature of the additional RF interference generated by the PLT will be dependent on the precise implementation, it is likely that it will manifest itself as random noise at the receiver output.

4 Relevant Recommendations

The following is a list of existing ITU Recommendations that are relevant to the subject of broadcast protection from PLT.

- Recommendation ITU-R BS.412 – Planning standards for terrestrial FM sound broadcasting at VHF
- Recommendation ITU-R BS.415 – Minimum performance specifications for low-cost sound-broadcasting receivers
- Recommendation ITU-R BS.560 – Radio-frequency protection ratios in LF, MF and HF broadcasting
- Recommendation ITU-R BS.703 – Characteristics of AM sound broadcasting reference receivers for planning purposes
- Recommendation ITU-R BS.1514 – System for digital sound broadcasting in the broadcasting bands below 30 MHz
- Recommendation ITU-R BS.1615 – “Planning parameters” for digital sound broadcasting at frequencies below 30 MHz
- Recommendation ITU-R BT.417 – Minimum field strengths for which protection may be sought in planning an analogue terrestrial television service

- Recommendation ITU-R BT.655 – Radio-frequency protection ratios for AM vestigial sideband terrestrial television systems interfered with by unwanted analogue vision signals and their associated sound signals
- Recommendation ITU-R P.372 – Radio noise
- Recommendation ITU-R BT.1786 (BS.1786) – Criterion to assess the impact of interference to the terrestrial broadcasting service

5 Planning criteria and regulatory arrangements

For most types of radiocommunications the estimation of the quality and reliability of a radio circuit will include a complete link budget including the characteristics of the transmitter and receiver and the respective antennas as well as external factors such as noise and interference. With this information together with the requirements and capabilities of the modulation method the circuit performance may be predicted.

Predicting the overall performance of the broadcast circuit is more difficult; the broadcaster only has control of the design and operation of the transmitter system and its antenna. While holding the requirement to deliver a broadcasting service of acceptable quality to a designated area, the broadcaster has no knowledge of, or direct influence on, the performance of the receiver and its antenna.

More appropriately a signal field strength may be defined as a design target for the broadcaster who may assume that receiver locations served with at least this field strength will provide acceptable quality, relying on the listener to provide an adequate receiver and antenna.

6 Noise considerations

Recommendation ITU-R P.372-9 provides the most recent estimates of noise levels across the spectrum for man-made, atmospheric and cosmic radio noise.

It is necessary to consider the combination of noise internal to the receiving system and external noise entering through the antenna. External noise may be from lightning, from the galaxy or from man-made sources such as electrical machinery. In most situations it is man-made noise that dominates, although there are situations at low-noise radio sites, for example, where atmospheric and cosmic noise may be the limiting noise level. It is not expected that the noise level caused by natural sources will have changed since the advent of the models in Recommendation ITU-R P.372-9. However, man-made noise may change according to industrial activities.

The internal noise level may be determined from the receiver noise figure, taking into account the antenna performance. This is used to give an equivalent incident field strength.

Galactic noise is not significant. In temperate latitudes noise due to lightning is dominant at some times, particularly after dark in summer, and the importance of noise from lightning increases at lower latitudes. Noise due to man-made sources is described for 4 environmental categories.

7 Environmental considerations

The broadcasting services are planned and operated to provide a level of signal at a target location which is adequate to offer an acceptable quality of service at that location. At is simplest this means achieving a signal strength which will give a sufficient margin above the prevailing noise. If it is required to maintain the quality of service and hence this margin in the face of an increase in the noise level it is necessary to increase the transmitter power by the same amount. Clearly this will have an impact not only on the spectrum and its availability for other services, it will also represent an increase in energy usage.

8 Analysis

8.1 Broadcasting bands

The frequency allocations available to the broadcasting service as defined in Article 5 of the Radio Regulations are listed below (ignoring region variations in the frequency allocations).

- 148.5-283.5 kHz
- 525-1 705 kHz
- 2 300-2 498 kHz
- 3 200-3 400 kHz
- 3 900-4 000 kHz
- 4 750-4 995 kHz
- 5 005-5 060 kHz
- 5 900-6 200 kHz
- 7 200-7 450 kHz
- 9 400-9 900 kHz
- 11 600-12 100 kHz
- 13 570-13 870 kHz
- 15 100-15 800 kHz
- 17 480-17 900 kHz
- 18 900-19 020 kHz
- 21 450-21 850 kHz
- 25 670-26 100 kHz
- 47-72 MHz
- 76-80 MHz.

8.2 Protection requirements for broadcasting

The planning of the broadcasting services is often based upon noise-limited reception. The noise limitation is frequently set by man-made noise in the LF, MF, and HF bands. In the VHF band, the thermal noise floor of the receiving system becomes prominent. Recommendation ITU-R BT.1786 provides a criterion to protect the BS from interference caused by emissions from devices in the bands allocated to the BS. The Recommendation should be applied to PLT devices for all frequencies utilized by the broadcasting service to ensure protection from interference. The criterion specifies that the total interference to systems operating in the broadcasting service, from all sources of interference (PLT devices included) should at no time exceed one per cent of the total receiving system noise power. Since the environmental noise dominates at lower frequencies, it may be more appropriate to base the protection requirement on the environmental noise rather that the receiver noise. This section discusses broadcast receivers and develops appropriate protection criteria for each frequency band used by the broadcasting service below 80 MHz.

8.3 Receiver sensitivity

Using the AM bands as an example, the sensitivity of AM sound broadcast receivers is defined in Recommendation ITU-R BS.703 (Reference receivers for planning purposes). It is defined as the minimum usable field strength, using a built-in antenna (even if a terminal for an external antenna is provided), and for a receiving quality of: 26 dB *AF S*/*N*, with 30% modulation, in the absence of external noise. The values are as follows:

LF: 66 dB(μV/m),

MF: 60 dB(μV/m),

HF: 40 dB(μV/m).

8.4 Receiver noise level and acceptable interference level

To estimate deterioration in receiver sensitivity from co-channel interference, or to estimate the acceptable co-channel interference level, it is essential to know the receiver noise level, which consists of internal and external noise, rather than the receiver sensitivity. If the co-channel interference power is the same level as the original receiver noise, the resultant noise power increases twofold (3 dB) and the sensitivity is deteriorated by 3 dB (neglecting the difference of noise waveforms). The effective sensitivity is essentially determined by the total noise.

8.5 Receiver internal (intrinsic) noise

The receiver external noise and interference level are usually expressed as field strength. Accordingly, for ease of comparison, it is convenient also to express the receiver internal noise as an equivalent field strength (as if it were being received by a noiseless receiver through a specified antenna).

Receiver internal noise level, corresponding to receivers, whose sensitivities are specified in the previous paragraph 1, can be assumed to be:

$$AF\ S/N\,(\text{dB}) = RF\ C/N\,(\text{dB}) + \text{modulation degree}\,(\text{dB})$$

Substituting the conditions: *AF S*/*N* = 26 dB, and modulation degree = 30% (–10.5 dB), *RF C*/*N* which corresponds to the minimum usable field strength is 36.5 dB. Accordingly, the field strength equivalent to the receiver internal noise is 36.5 dB below the minimum usable field strength.
That is:

LF: 29.5 dB(μV/m),

MF: 23.5 dB(μV/m),

HF: 3.5 dB(μV/m).

Although this receiver internal noise is calculated using analogue receiver sensitivity, these results also apply to digital receivers when the bandwidth differences are taken into account.

8.6 Receiver external noise and overall noise

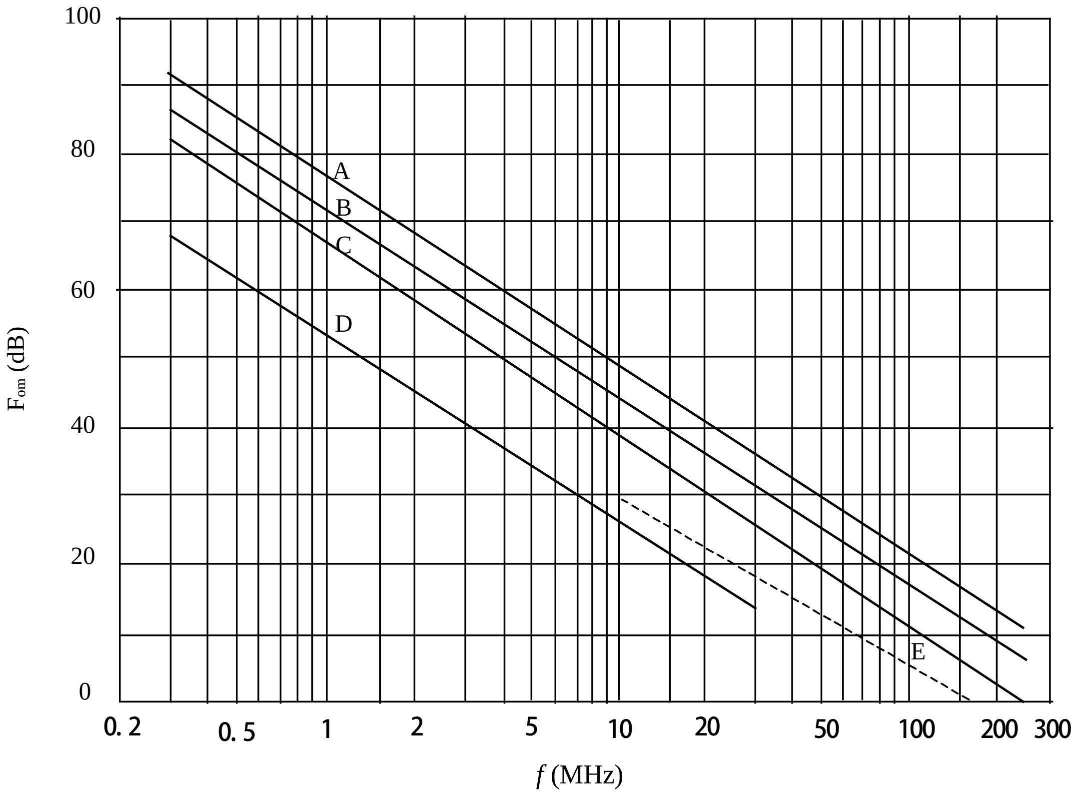
Receiver noise usually includes external noise that is received through the receiving antenna besides receiver internal noise generated in the receiver. The external noise for receivers operating below 80 MHz includes man-made, cosmic noise and below 30 MHz atmospheric noise.

8.6.1 Man-made noise

Figure 1 (which is taken from Figure 10 of Recommendation ITU-R P.372) shows a summary of man-made noise in various types of environment.

FIGURE 1

Median values of man-made noise power for a short vertical loss-less grounded monopole antenna (*Recommendation ITU-R P.372-9 "Radio noise", Figure 10*)



Environmental categories: A: City; B: Residential; C: Rural; D: Quiet rural; E: Cosmic noise

8.6.2 Atmospheric noise due to lightning

Recommendation ITU-R P.372 also gives predictions for the noise due to lightning and its variation with location, season, and time of day.

8.6.3 Comparison between man-made noise and atmospheric noise

It is expected that the majority of broadcast receivers will be located in residential areas, so that curve B of Figure 1 is appropriate for use. Comparison of these man-made noise levels with those of noise due to lightning shows that at MF and HF noise from man-made sources will usually dominate in temperate latitudes, but that in tropical regions increased noise level due to lightning may occur. In the upper part of the HF band and at VHF man-made noise will dominate.

Recommendation ITU-R P.372-9 expresses the average strength of each kind of external noise when received through a lossless short vertical monopole antenna with a perfect ground plane by comparing it with the thermal noise level (kT_o). Field strengths can be calculated as shown in Section 8.8 below. It is convenient, therefore, to convert the receiver internal noise level into equivalent field strength (*Eri*), as mentioned above, based on an identical antenna.

Equivalent field strength of the receiver (overall) noise (*Ert*) is expressed by the field strength corresponding to the power sum of the above *Eri* and average field strength of the external noise (*Ere*), *i.e.*:

$$Ert^2 = Eri^2 + Ere^2 \qquad (1)$$

When co-channel interference of field strength, *Eu*, is superposed on this *Ert*, the equivalent field strength of the receiver noise power increases to *Ertu*; corresponding to the power sum of *Ert* and *Eu*, *i.e.:*

$$Ertu^2 = Ert^2 + Eu^2 \qquad (2)$$

When *Eu* is 20 dB lower than *Ert*, receiver sensitivity deteriorates by 0.05 dB. That is, in order to limit the receiver sensitivity deterioration due to co-channel interference (*Eu*) within 0.05 dB, *Eu* should be 20 dB lower than equivalent field strength of the receiver (overall) noise (*Ert*).

Receiver internal noise in Section 8.5 above is calculated using the receiver sensitivity with a built-in antenna. However, the sensitivity figures in Section 8.5 are significantly improved by using an external antenna, such as a short wire extended in the room. Taking this improvement and low loss performance in the antenna matching of VHF receivers into account, external noise, whose minimum value is determined by the man-made noise, is considered the major component of receiver noise in receivers operating below 80 MHz.

8.7 Equivalent field strength of receiver noise

With the above antenna condition defined in Recommendation ITU-R P.372-9, a lossless short vertical monopole antenna with perfect ground plane, the received power (P_r) from a field strength *E* is expressed by:

$$P_r = E^2 \lambda^2 / (640\pi^2) \qquad (3)$$

where:

P_r: maximum available received power (W)

E: field strength (V/m)

λ: wavelength (m) = $3 \times 10^2 / f$

f: frequency (MHz).

Substituting kT_ob into the above P_r, equivalent field strength of the thermal noise; $E(kT_ob)$ is given by:

$$E(kT_ob) = 20 \log f + 10 \log b - 95.5 \text{ dB } (\mu\text{V/m}) \qquad (4)$$

where:

$E(kT_ob)$: equivalent field strength of the thermal noise: kT_ob dB(μV/m)

k: Boltzmann's constant = 1.38×10^{-23} J/K

T_o: reference temperature = 288 K

b: receiver effective noise bandwidth (Hz).

Recommendation ITU-R P.372-9 expresses the average strength of each kind of external noise by comparing it with the thermal noise level (F_{am} dB relative to kT_o). That is, each field strength is obtained as F_{am} dB above $E(kT_ob)$ dB(μV/m).

8.8 External noise

Recommendation ITU-R P.372-9 expresses each of average strength of atmospheric noise, man-made noise, and cosmic noise comparing with the thermal noise level (F_{am} dB relative to kT_o) when they are received through a lossless short vertical monopole with a perfectly grounded plane. In all cases results are consistent with a linear variation of the median value, F_{am}, with frequency f of the form:

$$F_{am} = c - d \log f \qquad \text{(dB relative to } kT_o\text{)} \qquad (5)$$

With f expressed in MHz, c and d take the values given in Table 1. Note that equation (5) is valid in the range 300 kHz to 80 MHz for all the environmental categories except for quiet rural which is valid to 30 MHz.

TABLE 1

Values of the constants *c* and *d*

Environmental category	*c*	*d*
City	76.8	27.7
Residential	72.5	27.7
Rural	67.2	27.7
Quiet rural	53.6	28.6

Since the above are received values with lossless short vertical monopole above a perfect ground plane, the vertical component of the r.m.s. field strength is obtained as F_{am} dB above $E(kT_ob)$ dB given by equation (4).

$$E_n = F_{am} + 20 \log f + 10 \log b - 95.5 \qquad \text{dB(μV/m)} \qquad (6)$$

where:

E_n: field strength in bandwidth b, and

f: centre frequency (MHz)

b: receiver effective noise bandwidth (Hz).

By substituting F_{am} expressed by equation (5) into equation (6),

$$E_n = c - d \log f + 20 \log f + 10 \log b - 95.5 \qquad \text{dB(μV/m)} \qquad (7)$$

8.9 Protection requirement for the broadcasting service below 80 MHz

When an external antenna is used, external noise is the major receiver noise. With a built-in-antenna, external noise is the major factor in business and residential areas. Even in rural areas the external noise is significant. The minimum level of external noise is determined by the man-made noise as this is the dominant factor when the atmospheric noise fades. Since the minimum value of external noise is determined by the man-made noise, the protection requirement for field strength is also determined by man-made noise.

In order to limit receiver sensitivity deterioration within 0.05 dB, the requirement for protecting the broadcasting service should be 20 dB lower than E_n. Furthermore, the protection requirement can be expressed in terms of a maximum field strength density of dB(μV/m/MHz) with b = 1 MHz. The protection requirement is expressed by,

$$\text{Maximum field strength density} = g + h \log f \qquad \text{dB}(\mu\text{V/m/MHz}) \qquad (8)$$

where:

$g = c - 55.5$

$h = 20 - d$

g and h take the values given in Table 2.

TABLE 2

Values of the constants *g* and *h*

Environmental category	*g*	*h*
City	21.3	–7.7
Residential	17.0	–7.7
Rural	11.7	–7.7
Quiet rural	–1.9	–8.6

The protection requirement for the broadcasting service below 80 MHz in terms of maximum field strength density at the broadcast receiver antenna is tabulated in Table 3.

TABLE 3

Maximum interference field-strength densities at the broadcast receiving system

Broadcast frequency band*	**Maximum interference field-strength density dB(μV/m/MHz)****			
	City	**Residential**	**Rural**	**Quiet rural**
148.5-283.5 kHz	27.7	23.4	18.1	5.2
525-1 705 kHz	23.5	19.2	13.9	0.5
2 300-2 498 kHz	18.5	14.2	8.9	–5.0
3 200-3 400 kHz	17.4	13.1	7.8	–6.2
3 900-4 000 kHz	16.7	12.4	7.1	–7.0
4 750-4 995 kHz	16.1	11.8	6.5	–7.7
5 005-5 060 kHz	15.9	11.6	6.3	–7.9
5 900-6 200 kHz	15.4	11.1	5.8	–8.5
7 200-7 450 kHz	14.7	10.4	5.1	–9.3
9 400-9 900 kHz	13.8	9.5	4.2	–10.3
11 600-12 100 kHz	13.1	8.8	3.5	–11.1
13 570-13 870 kHz	12.6	8.3	3.0	–11.6
15 100-15 800 kHz	12.2	7.9	2.6	–12.0
17 480-17 900 kHz	11.7	7.4	2.1	–12.6
18 900-19 200 kHz	11.5	7.2	1.9	–12.9
21 450-21 850 kHz	11.0	6.7	1.4	–13.4
25 670-26 100 kHz	10.4	6.1	0.8	–14.0
47-72 MHz	8.4	4.1	–1.2	–16.3
76-80 MHz	6.8	2.5	–2.8	–18.1

* Broadcast frequency bands do not include regional variations given in Article 5 of the Radio Regulations.

** Values derived from Recommendations ITU-R P.372 and ITU-R BT.1786.

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